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"... the great Washington is still the American idol. No other President, no other statesman, has won the universal homage of the people as he did. Washington has no rival—he can have no rival—in holding the first place in the great American heart."—ELSON.

Of Lincoln, James Russell Lowell said: "A man of humble birth and ungainly manners, of little culture beyond what his own genius supplied, the wisest statesman and most pregnant speaker of [his] generation."

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SCHOOL SCIENCE AND MATHEMATICS

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SUPPLY AND DEMAND OF TECHNICAL PERSONNEL IN AMERICAN INDUSTRY*

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In 1945, Dr. Vannevar Bush, then Director of the Office of Scientific Research and Development, directed to the President of the United States a report under the title "Science, the Endless Frontier." This report pointed out the importance of scientific research for our national security and our public welfare, and proposed the encouragement of research, both basic and applied, mainly by increasing the supply of scientific talent. It was stated that a deficit of approximately 150,000 graduates in science and technology had accumulated during the war; a National Science Foundation was proposed to grant scholarships and fellowships to students in science.

These recommendations have been carried out only in part. The great concern about the supply of scientific men began to wane when unprecedented numbers of students entered college after the war under the GI program, Many felt during 1949 and 1950 that the supply of technical personnel was reaching equilibrium with the demand. However, during the last year or two, a critical situation has developed because of continued increase in demand along with an alarming decrease in the supply of technical men.

I propose to show some of the facts and figures on this disparity of supply and demand, to indicate the critical importance of this situation to our national economy and security, and to show how the high-school teachers of mathematics and sciences have an important role to play in helping to solve this problem. I shall talk to you mainly about chemists and chemical engineers in industrial research, the field with which I am best acquainted.

* Presented at the 52nd Annual Convention of the Central Association of Science and Mathematics Teachers, Edgewater Beach Hotel, Chicago, November 28, 1952.

Technical Manpower

First of all, let's briefly consider the broad picture of our technically trained manpower. Of the 60 million people in civilian employment in the United States, only 600,000, or 1%, are engineers and scientists. Two-thirds of these people are engineers—electrical, civil, mechanical, etc.—primarily engaged in building and operating the complicated equipment of our modern industry. These people are increasingly important to the nation and are needed at the rate of 30,000 new men per year (1). Much of what I shall say about chemists and chemical engineers applies also to the broader fields of engineering.

Narrowing our attention specifically to chemistry and chemical engineering, let's take a look at the demand for men trained in these fields. Between 1940 and 1951, there has been a startling increase in the number of persons working as chemists and chemical engineers. As shown in Table I, the number of chemists almost doubled and the number of chemical engineers increased threefold during the eleven-

Table I. U.S. Employment of Chemists and Chemical Engineers

	1940	1951
Chemists	60,000	100,000
Chemical Engineers	15,000	45,000
Total	75,000	145,000

year period (2, 3). The totals show an average annual increase of 6,400, which represents an acceleration of the marked expansion in scientific research and development in industry and government that has been taking place in this country since the First World War.

Most prominent among the industries that have increased their technical staffs during the past ten years are petroleum and chemicals. The chemical industry more than any other depends entirely on the work of technical men—mainly chemists and chemical engineers—to develop an ever-expanding variety of products. This industry during the past ten years has increased almost four-fold in size, as compared with a 75% increase for all manufacturing industries (4).

The demand for technical men has also increased sharply in government research. A tremendous program of research on ordnance equipment of all kinds—jet engines, fuels and lubricants, explosives and propellants, and atomic energy—requires the services of large numbers of technical men, not only chemists and chemical engineers, but other varieties of technical men as well.

The types of activities of chemists and chemical engineers combined are given in Table II (4). Actually, a greater proportion of

TABLE II. TYPE OF ACTIVITY

Research and Development	37%
Administration	20%
Analysis and Testing	16%
Production	10%
Teaching	9%
Technical Service and Sales	2%
Other	6%

chemical engineers than chemists are engaged in administrative activities and production, but fewer in teaching. The largest share of both work on research and development.

Research and development also employs technically trained men of other disciplines. Table III shows the distribution of all types of technical men in industrial research in 1950 (5). Chemists and chemical engineers constitute almost two-thirds of all industrial-research

TABLE III. INDUSTRIAL-RESEARCH PERSONNEL (1950)

	Number	Per Cent
Chemists and Chemical Engineers	43,450	62
Other Engineers	15,300	22
Physicists	2,950	4
Metallurgists	2,675	4
Biologists	1,675	2
Geologists	700	1
Unclassified	3,800	5
Total	70,550	100

personnel. Other engineers—electrical, mechanical, civil, and so forth—account for more than half of the remainder.

If we wish to take account of all research activities in the country, we must also consider research being carried out by government agencies, in universities, and in other institutions. The total number in these areas is hardly more than 50% of the 70,000 engaged in industrial research. Thus, the total number of scientific research men in this country is on the order of 100,000 persons. This extremely small segment of our national labor force is responsible for the tremendous strides in our industrial progress.

The contribution of research and development men can be illustrated by an example taken from the petroleum industry. Gasoline consumption in this country is about ten times that of 1920. One might presume that petroleum is found in the ground by simply drilling holes, and that it does not require research to get gasoline

from it. That is true only to a very limited degree. Were it not for the research by geologists and geophysicists aimed at finding increased amounts of crude oil, and the research of chemists and chemical engineers aimed at increasing the quality and quantity of gasoline from each barrel of crude oil, we could not supply more than 25% of the present gasoline requirements.

As other results of scientific research, I need only mention the great advances in electronics that add greatly to our means of communication and amusement, plastics that serve new uses and supplement our metals, synthetic rubber and synthetic fibers superior to the natural products, and improvements in the efficiency of agriculture that permit the efforts of one man to supply food for five persons, rather than for only three, as a generation ago. Among other products of research are insecticides, new drugs to combat an increasingly greater proportion of the diseases to which man is subject, and better and more effective weapons to protect our country from foreign attack.

If America is to continue to expand its industrial capacities, to further elevate the standard of living of its people, and to protect them from possible foreign attack, it must be assured of an increasing supply of technically trained manpower.

The Supply Problem

The supply of technical men is always closely tied to the enrollment of male students in our colleges and universities. Table IV shows annual figures for male attendance since 1940, and the esti-

Table IV. Male Enrollment in Colleges and Universities (Thousands)

1940—850	1947—1,600
1941—900	1948—1,800
1942—800	1949—1,825
1943—650	1950—1,850
1944—600	1951—1,700
1945—750	1952—1,600
1946—900	1953—1,350

mated attendance for the current school year (6). Broadly, the general trend of college attendance is upward, because of increasing population and the increasing percentage of men attending college. If these data are compared with the long-range trend in college attendance, we find that the figure for 1952 is about in line. The decline in attendance during the war years appears to be largely compensated by increased attendance during the postwar years. Another factor—the decreased birth rate during the depression of the early 1930's—

currently contributes to subnormal college enrollment. Estimates for the next few years are that college enrollment will level out at about the 1953 figure and will increase gradually thereafter.

The annual net increases in chemists and chemical engineers available for employment over the period 1946–1955 are shown in Table V (4). These figures are based on graduations, up to 1951, with deductions for estimated losses due to retirement and death. Graduations for 1953 to 1955 are estimated from current attendance with

TABLE V. NET INCREASES IN CHEMISTS AND CHEMICAL ENGINEERS

1946— 5,700	1951—11,600
1947— 7,400	1952— 8,800
1948— 8,400	1953— 5,600
1949— 8,600	1954— 4,400
1950—10,300	1955— 2,800

allowance for attrition during college. Such estimates involve considerable uncertainty, but they are valid for showing major trends. These data show peak numbers in 1950 and 1951, and a sharp drop beginning in 1952. Net increases during the years 1947–1952 exceeded the average demand of 6,400 derived from Table I. However, beginning in 1953, additions to the profession are estimated to drop below this figure, and predictions for 1954 and 1955 are markedly lower. A similar study for all fields of engineering shows the same trend: Beginning in 1952, the number of available new engineers drops below the annual requirement of 30,000 estimated by the Engineers Manpower Council (1).

In addition to this discouraging picture as to the number of men available, the supply is further decreased by the draft and ROTC. Data on 1951 college graduates showed that 17% of science and engineering majors went into military service (7). The attitude of draft officials in the recent past and the recent emphasis on ROTC programs by the military indicate that an increased proportion of technical graduates will be lost temporarily from professional employment.

Comparison of Tables IV and V reveals another very disturbing trend: The number of students graduating in chemistry and chemical engineering is declining faster than the total male college enrollment. This trend is borne out by the fact that the percentage of high-school graduates going into engineering in 1950 was 25% below the average for 1936–40 (1, 4). Many have concluded that an important factor in this decrease was the publication in 1950 by the Bureau of Labor Statistics of the so-called Wall Chart No. 10, which stated that there was an oversupply of science majors and engineers at that time (1).

Repetition of this conclusion in other publications led to warnings by schools and vocational advisers. It is probable that this was an important reason for the low registration of entering engineering students in 1950, but I doubt whether it had much lasting influence. There has been much publicity since that time emphasizing the strong demand for technical men.

It is likely that the uncertainty regarding draft status that faces young men at 18 and 19 is a more significant reason for decreased specialization in science and engineering. A youth at this period is apt to be dubious about entering a profession that requires from four to seven years of training when he feels that he may be called into the Army. The ready availability of jobs for high-school graduates offers an immediate prospect of good earnings, as opposed to the uncertainties of extended training for a profession. It is indeed unfortunate that the administration of compulsory military service is so unpredictable as to deprive a young man of the opportunity to make plans on a long-term basis (8).

In the next few years, the demand for chemists and chemical engineers will be substantially greater than the estimated supply. Because of the increased number of men needed for industrial research, and particularly because of the demands of government research, the requirements during the next few years are about double those of a decade ago. Opposed to this, the estimated net supply is dropping to perhaps half of what it was ten years ago.

Proposed Solutions

Various proposals have been made as to means of closing the gap between the supply and demand for technical men. These suggestions vary rather widely in character and merit.

It is maintained by some that technically trained men are not being employed at the highest level of their potentialities. The proposed solution is to provide assistants who are not technically trained to carry out parts of the job for which technical training is not really required—routine laboratory tests and calculations, administrative details, and so forth. Moves in this direction were started during the last war and even before. It is difficult to appraise the extent to which the efficiency of technical men may be increased further by the use of laboratory assistants, operators, clerks, and draftsmen. Among the major industrial research laboratories, considerable attention has been given to this sort of thing, and there is some question whether further efforts in this direction would be profitable.

The research laboratories of my own company, for example, have a large corps of laboratory assistants who are not college trained.

Operation of pilot plants is carried out around the clock entirely by nontechnical operators. Clerks are used for routine calculations. Altogether, the nontechnical staff numbers 1.3 for each technically trained man. All of these nontechnical people are engaged in actual research operations and are in addition to the substantial number of service and stenographic personnel and craftsmen needed for the operation of the laboratories. Perhaps in less highly organized laboratories there is further opportunity to upgrade the work of the scientists and engineers by nonprofessional assistants, and this point should be given proper consideration (9).

It is frequently stated that, under the laws of supply and demand, increasing the salaries for technical men will be effective in increasing the supply. Undoubtedly this factor is at work now. Starting salaries have increased substantially, even after allowing for increased living costs, and typical policy among industrial research laboratories is to increase salaries steadily with experience. The contrast in salaries between scientific men in industry and those in teaching frequently presents a real problem in keeping the teaching profession adequately staffed.

A potential source of technical personnel may be tapped by the increased use of women in research. The number of women in scientific work is increasing. The situation varies among the different industries; in many types of engineering work there are not many women, but substantial numbers are employed in the pharmaceutical field. It is a cold fact that there is some resistance to employment of women because of their lack of permanence. This is a disadvantage, but perhaps not one of sufficient moment to impede the entry of greater numbers of women into the profession. I do not know of any organized movement to accelerate the entry of women into scientific work; perhaps it is best not to handle the matter that way, but to let nature take its course as governed by the laws of supply and demand (10).

If the taking of trained scientists and engineers for military service on assignments that are nontechnical in nature could be minimized, a substantial increase in the number of such men available for civilian employment would result. The Army requires technical men of various kinds—engineers particularly—and should by all means take as many as it needs. However, this country very badly needs an intelligent policy that will distinguish between general military service and the use of technical men in their own line in the Army. Technical training is a valuable asset to the country at large—an asset that requires years to build up. Russia has recognized this fact and has an estimated 1,700,000 men under training in 1,500 technical institutes (4). Proper consideration of national security leads to the

conclusion that it is highly important for technically trained men to be available in time of war to back up the military machine with the weapons and equipment required. We cannot fight a war effectively if we don't have adequate technical staffs for industry, and recent history shows that the military is more and more dependent on research and development.

An example of the lack of sound planning in this country is the indiscriminate effort of military personnel to bring college men into the ROTC program. It is reported quite generally that freshmen are being urged into the ROTC by the argument that they will surely be drafted upon graduation and will be better off with officer training. It appears that men majoring in science and engineering are as much targets in this drive as other students. With our prospective shortage of technical men, this is indeed a suicidal policy.

As means of encouraging students into technical training, a great deal of attention has been given to the matter of fellowships and scholarships. Because of the acute shortage of men with postgraduate training, more emphasis has been given to fellowships for men studying for M.S. and Ph.D. degrees than to scholarships for undergraduates. Many industrial companies have fellowship programs, most large universities also provide fellowships, and the National Science Foundation is granting a number of fellowships beginning this year. In the major universities at least, financial assistance to postgraduate students in science and engineering is no problem, but fewer undergraduate scholarships are available. The National Science Foundation does not grant scholarships to undergraduates, presumably because of the limited support that Congress has granted to the Foundation. The Bush report of 1945 recommended that 24,000 scholarships be given to qualified students throughout their college work. It remains to be seen whether the current program of the National Science Foundation will be expanded to include any program approaching this.

The Role of the High-School Teacher

Initial consideration of the problem of attracting qualified students into technical fields considered only students at the college and postgraduate levels. More recently, emphasis has been placed in the importance of the high school in providing the stimulus and vocational guidance toward the technical fields. This seems appropriate because the choice of vocation is frequently made in the high school and, when the student enters college, he has often already decided what type of course he is going to pursue.

The persons who are in the most strategic position to stimulate and advise high-school students who have technical aptitudes are the

teachers of mathematics and science. The genuine enthusiasm manifested, the quality of the teaching effort, and the technical facilities of the school are undoubtedly prime factors in stimulation. How to select and influence students toward science and engineering is no easy problem and one that requires judgement and discrimination. As prerequisites, the student must have relatively high intelligence, imagination, ingenuity, and an inquiring mind. The capacity to influence and get along well with people helps in science as in other human activities. This is quite a list, and it is not easy to measure any of these things. Certainly the scientific field requires the quantitative type of mind, and students who are proficient in mathematics are naturally indicated. Interest in science may also be fostered by extracurricular activities of the high school, such as science clubs, camera clubs, and visits to industrial laboratories and plants. Even below high-school age, the broadening interests of the Boy Scout program in natural sciences, under capable adult leadership, tends to aim younger people toward the scientific professions.

I am not urging a campaign to high pressure students into science and engineering. It would be a catastrophe if a host of unqualified students were talked into going into this area of training. It should be just as much the responsibility of the high-school teacher to direct away from science and engineering students who do not appear to be qualified. The standards of performance in science and engineering courses are high, and the attrition runs as high as 50% of the students that enter such courses. It is only those who have the aptitudes, abilities, and willingness to work hard who should enter this field.

Authoritative estimates made on the basis of the Army intelligence tests of World War II show that only about 15% of the population has the level of intelligence required for college science and engineering training (9). Nevertheless, a substantial proportion of high-school graduates having these intellectual requirements do not go to college (11). The solution of the problem of the supply of technical personnel—as well as of such other intellectual workers as doctors and teachers—is not to increase indiscriminately the proportion of high-school students entering college, but to enroll the bright youngsters who would otherwise not enter college.

There are many misconceptions about what sort of work scientists and engineers do. The Manpower Committee of the American Chemical Society, the Engineers Manpower Commission of the Engineers Joint Council, and the Research Committee of the National Association of Manufacturers are undertaking programs to provide information for high-school students on the kinds of work carried out by scientists and engineers and the potentialities of a career in this field. Booklets may be obtained from each of these or-

ganizations. Intensive work and co-operation on the part of members of the profession, high-school teachers, governmental agencies, and others is needed to solve the problem of an adequate supply of scientific personnel so essential to the continuation of our welfare and security.

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MAP MAKING

The man who designs maps is still the central character in the long process of map making—and this fellow hasn't kept pace with those who gather and reproduce the scientific data on maps.

Prof. Arthur Robinson of the University of Wisconsin geography department presents this opinion and examines the error of traditional map design in the latest book from the UW Press, *The Look of Maps*.

In the volume, published Dec. 5, Robinson points out that many of the conventional symbols on maps are logical and stand functional analysis, but others bear not the slightest relation to the things they depict or to other symbols with which they are linked.

"Most of the graphic design conventions were established prior to the current growing acceptance of functional design as the basis of creative effort," he explains. The new philosophy has not been generally recognized by cartographers, he says, and thinks this is due not to congenital conservatism on their part but to an inability to find the time for research on visual perception.

"There are, however, indications that efforts and thoughts are being expended in this direction," Robinson says in his effort to show not only what is known by cartographers but especially what is needed to be known for good visual presentation in the form of maps.

MASS EDUCATION*

D. M. MacMaster
Director, Museum of Science and Industry, Chicago, Ill.

Whenever we hear this word "education" we are inclined to assume that the reference is to formal education. This, of course, is quite understandable since each of us has been exposed for a greater or lesser period to the techniques and practices of the formal school.

Closer examination of the situation will reveal, of course, that much education is accomplished outside the classroom and formal educators were among the first to recognize and acknowledge this fact.

Constant and fruitful efforts are being made by formal teachers further to improve the effectiveness of their teaching methods, and there is no doubt that the formal school will in the future continue as it has in the past to become a more and more significant contributor to society. It is also true that formal education will never be replaced or displaced by mass education. Nevertheless, it is my conviction and prediction that mass education will assume a place of importance in the future relatively greater even than it has in the past. I don't mean to imply that these two activities are competitive in any sense. On the contrary, they are complementary to each other.

I do intend to indicate strongly, however, that in my opinion we can look forward toward mass education becoming an increasingly effective and significant factor. With unprecedented progress and development in all forms of communication and transportation, there is little doubt that television, radio, motion pictures, newspapers and other publications, expositions, museums and other mass media will reach and influence more and more people.

This matter becomes one of considerable personal concern and interest to the members of this society since it opens tremendous and far-reaching opportunities to educators. It is from the ranks of the educators that those to engage in broadening mass educational activities should be drawn. With the FCC allocating television channels for educational purposes, this one field alone offers as great a potential to accomplish a significant educational job as any the world has ever known.

But these developments, by the same token, make it essential that formal educators recognize and understand the basic differences which exist between formal and mass education.

Because of these differences, what are accepted as successful tech-

* Presented at the Central Association of Science and Mathematics Teachers, Edgewater Beach Hotel, Chicago, Friday Nov. 28, 1952.

niques and methods in the classroom will prove almost certainly to be unsuccessful in mass media—and for very definite reasons.

In formal education all of the students in a given class are of roughly the same age and educational background. They have been brought forward from the age of 5 or 6 in a logical, sequential step-by-step process. Since, in general, schools draw their students from a relatively limited geographical area, the students are even of roughly the same social and economic group. Other than the expected distribution over a normal probability curve, students in a given classroom comprise a relatively homogeneous group.

In the lower schools it is not necessarily the choice of the student or even of his parents that he is present. We have compulsory attendance laws which insure his presence. So what we have in most classrooms is a homogeneous, captive audience. But that's not all.

Over the years a number of ingenious devices which serve to motivate the student have been developed. Grades are given and, in general, students prefer to get good grades rather than poor ones. Even if grades are not given, someone has to decide at the end of the year whether or not each student is to be promoted to the next grade level and students tend to want to be promoted.

In spite of some indications to the contrary, parents do exert some motivating influence on their children. But even without parental pressure, the social pressure among students themselves has an influence. No youngster wants to be categorized as stupid by his fellows.

In the upper schools someone is paying the bill for the student's schooling, either the student himself, having earned the money, or his father. In either case there is a tendency on someone's part to see to it that the investment produces some result. In many cases the student is learning to earn a living and his desire for financial, business or professional success in later life is a strong factor in influencing his efforts while in school.

Finally, if all of these motivating influences fail, there is the opportunity in the formal school to resort to disciplinary action.

The significant point is that for reasons completely removed from the effectiveness or ineffectiveness of the teacher, the student in the formal school is motivated to learn.

I do not imply for a moment that teachers are generally ineffective. The fact that great meetings such as this one are held by teachers during what might otherwise be a holiday period is an indication of the interest and enthusiasm and ability that is typical of the teaching profession.

The fact remains, however, that there are forces at work in the school which tend to cause students to apply themselves to the task at

hand regardless of how dull or uninspired the classroom presentation might be.

As a consequence, it is therefore possible to have what is by the accepted standards a successful school system—successful, for instance, in that its students rate favorably in accomplishment and understanding in nationwide standardized tests—in spite of the fact that the quality of the teaching in the system may be poor.

The situation is a different one in the field of mass education. In mass education—whether it be television, magazines, the museum or whatnot—the audience is not captive. In fact, it is most illusive. Since no one is required to watch a program or read an article or visit a museum, every effort must be made to win the audience through an attractive and effective presentation, and to hold the audience once it is won. Holding the audience is more difficult than attracting it. It requires eternal vigilance in never allowing the presentation to become dull or uninteresting for a moment. It requires gripping the attention of the audience from instant to instant. A few moments of dull presentation in radio or television means that the viewer flips a switch and is gone forever. A good lead paragraph in a magazine article followed by three dull paragraphs—and watch yourself the next time it happens to you—the page is turned even without consciously knowing you have done it.

In mass education you are dealing with a completely heterogeneous audience of all ages, all educational and social backgrounds. There are no grades, no promotions, no social or parental pressures, no disciplinary opportunities, none of the motivating influences found in the classroom. Your prospective readers, listeners, viewers or visitors don't have to subject themselves to your presentation and they can leave it anytime they care to. You are up against tremendous competition for their time. As a result, mass education must use techniques not necessary in the school.

In mentioning some of these techniques, I am going to use the Museum of Science and Industry as my point of reference and confine myself to terminology related to the Museum. The same basic ideas which will be mentioned apply equally with appropriate changes in terminology to television, publications and other mass media. While I may be presumptive in saying this to this audience, it is my feeling that the more general application of these ideas to formal education would not be remiss.

In 1951, 1,853,000 people visited the Museum of Science and Industry and stayed, on the average, a little over three hours. During the current year attendance through yesterday was 13% ahead of the similar period of last year and indications are that our 1952 attend-

ance will exceed two million. In the event that you are not familiar with Museum attendance figures and, as a result, have no frame of reference in which to consider these, let me assure you that they are very large numbers. More than six million man-hours of visitor time will be spent in this Museum during this year.

Actually, it is not a museum in the classical meaning of the word. It is neither a repository for historic objects nor a place to collect and house scientific collections for comparative purposes.

On the contrary, it is a mass educational institution based on the premise that acquiring knowledge should be a pleasant experience. It is our observation that it is not necessary to be dull to be educational; in fact, it helps not to be. More effective education results from an interesting, appealing presentation.

Our basic approach is to accept people as they are—emotional human beings. We do not take the attitude that "this is good for you" or that "you ought to do it." Most of us don't do what we ought to do. We don't eat what we ought to eat, even though we know it would be good for us. We don't sleep when we ought to sleep. And since we at the Museum are dealing with large numbers of people very much like you and me, our attitude is "let's face it."

Our next step is to first give the visitor what he wants rather than what some academic arbiter thinks he should have. We have learned that by first giving him what he wants he will then accept what we want him to have.

We feel it is desirable to allow the visitor to become part of the presentation—to participate personally.

We feel it is desirable to use color, light, architectural qualities, the arts of the theater if you will. But these techniques of the stage are used not as ends in themselves but as vehicles to accomplish an educational purpose.

We feel that ideas and quality are far more important than size, that a large budget is no assurance of success, that mediocre material superbly presented is more effective than superb material poorly presented. Above all, we feel that if the student hasn't learned, the teacher hasn't taught.

We believe that if there is no audience there has been no accomplishment. We believe that endless rows of glass cases of perfect specimens are not an irresistible lure. We don't believe that standard wall colors, standard floor coverings, standardized lighting no matter how "logical," "efficient" and "practical" they may seem give rise to educational effectiveness. On the contrary, we are convinced they result in fatigue and boredom and, as a result, defeat the only purpose of the whole thing—the attraction and maintenance of visitor interest.

We feel that until one's attention and interest are caught and held, no educational result can be achieved.

We have observed that many factors which on the surface appear to be beside the point and unworthy of the attention of the educator have an important bearing on educational effectiveness. To mention just a few in the case of the Museum: the rules affecting visitors are made for the convenience of the visitor rather than the staff. The Museum is open from 9:30 A.M. until 7 P.M. on Sundays and holidays, rather than for a few hours in the early afternoon, because those are the days the people can come. Smoking is permitted throughout the building because many people want to smoke and they will leave after an hour if they are not permitted to do so. Maybe we wish they weren't that way, but the fact remains that they are.

Why do we work at this job; what is it designed to accomplish? First, and obviously, it is designed to bring home to large numbers of people in terms they can understand the basic technical stories of science and industry. But more important probably than that, it is to bring home to millions of youngsters and adults as well the Story of America. To give them a better understanding and appreciation of how science and industry operating under the freedoms that have characterized this country since its founding have succeeded in bringing to our people the highest standard of living the world has ever known.

And to those who would point out that this is only a material standard of living, that it is merely a matter of refrigerators and automobiles and pots and pans and that these are not really the important things of life, we like to point out that all of both public and private education, research, literature and the arts are dependent for their very existence on material accomplishment.

Earlier in these remarks I said that it is from the ranks of the educators that those to engage in broadening mass educational activities should be drawn. I didn't say they will be. In fact, they most certainly will not be unless and until the educators can produce results under the Ground Rules of the mass education situation. I don't believe they can change the situation but they can change their own mental attitudes and accept the facts as they exist.

If they do this, they will be opening tremendous new opportunities for themselves. But more important than that, they will be opening tremendous new educational opportunities for millions of people. If they insist on assuming that mass education can be accomplished without accepting and understanding how it differs from the situation which obtains in the formal school, they will have missed the greatest opportunity which has ever been presented to them.

B. SMITH HOPKINS

1873–1952

Professor Emeritus B. Smith Hopkins, of the Department of Chemistry, University of Illinois, passed away at Urbana, Illinois, in October, 1952.

In length of service Professor Hopkins was the senior member of the departmental editor staff of SCHOOL SCIENCE AND MATHEMATICS. He became editor for research in chemistry in April 1917, and his first article in this field was published the following month. Since that time until the spring of 1951 he continued to secure many worthwhile articles for publication under this heading. Few men have served the teaching profession so long and so well. His last great series of articles published in Volume 46 of *this Journal*, "Some War-Time Developments in Chemistry," will long be remembered by many of our readers.

Mr. Hopkins was born in Michigan, September 1, 1873. In 1896 he received the Bachelor of Arts degree from Albion College and the following year the A.M. Years later in 1927 he was called back to Albion to receive the honorary degree, Sc.D. He began his teaching career as a teacher of science in the Menominee, Michigan, high school in 1897. After teaching six years in high school and continuing his graduate work in college and university, he received the Ph.D. degree in 1906 from Johns Hopkins University. He then became professor of chemistry at Nebraska Wesleyan in 1906, went to Carroll in 1909, and became instructor at the University of Illinois in 1912. Here he advanced rapidly, becoming assistant professor in 1917, associate professor in 1920, and a full professor in 1923. His research in the field of chemistry is well known but, as is true of all great teachers, his influence was greatest through the personal inspiration and encouragement of the students who were privileged to work under his direction.

His numerous publications on osmotic pressure, the rare earths, luminescence, and many other related topics are well known. He was an active member of the American Chemical Society, the Electrochemical Society, the Illinois Academy of Science, the Central Association of Science and Mathematics Teachers, Phi Beta Kappa, Sigma Xi, and others. His text books in both the high school and college fields are used in schools and colleges everywhere. Numerous honors attest the high position held by Professor Hopkins in his chosen profession and in the hearts of his fellows.

RAY C. SOLIDAY
GLEN W. WARNER

GREAT LAKES—HOW THEY WERE FORMED*

Joseph E. Dickman

Midwest Mgr. of Encyclopaedia Britannica Films, Wilmette, Ill.

Boys and girls of the South Shore High School, I first want to thank you for giving up this holiday to take part in this afternoon's program. While you haven't been told just what is going to be done here this afternoon, and, by this time, must be a bit curious, let me say that we are here to see just how much we can learn about the formation of the Great Lakes in one short hour with the aid of a very fine color and sound motion picture on the subject, using the film's power of animation and live photography.

Just why are the Great Lakes important enough to justify our spending time on their past formation? I know you are interested at least in the one near you, since it provides you with a summer playground for swimming and maybe boating, not to mention an abundant and cheap supply of fairly pure water. You know, too, that it along with the other Great Lakes, Superior, Huron, Erie and Ontario, together with the St. Lawrence and Mississippi Rivers were convenient highways for the canoes of the early French Explorers (illustrated with a color 2×2 slide on the areas of French Exploration).

Maybe you don't quite realize how important the Great Lakes are to our present high standard of living. Do you know that the tonnage of freight carried on the Great Lakes is greater than the total freight carried in our foreign trade, well over 100 million tons, of which about 75 million is iron ore alone? Then there is coal and wheat and oil and limestone and machinery of all kinds carried in huge quantities at rates far below those of railroads or trucks, simply because the water highway is cheap—put there by nature.

Were these Great Lakes always there, if not how were they formed . . . and here we get to the interesting part of today's lesson, a film that will, in about ten minutes, do much more than I could with mere words. And speaking of words there are a few that I will now write on the board, so that when you hear them in the film you will be ready to attach even more meaning to them than you, perhaps, now do. They are *Glacier*, *Moraine*, *Glacial Till* or *Drift*, *Gouge*, *Striae*, *Bedrock*.

At this point the film is shown.

The opening scenes reveal that the Great Lakes reach more than

* A film-taught classroom demonstration given at the Geography Section Meeting of the Central Association of Science and Mathematics Teachers Convention at the Edgewater Beach Hotel.

1000 miles into the heart of North America. We learn that these large inland lakes are unique because, although their waters are fresh, no large rivers flow into them, and their drainage area is comparatively small. They drain into the Atlantic Ocean via the St. Lawrence River.

Next the film defines a glacier as a field or river of ice formed from snow in areas of perennial frost. Glaciers which existed in North America during the glacial epoch may have been two miles or more in depth, and were called continental glaciers. We see that the tremendous weight of these ice sheets or glaciers caused them to spread outward and southward until their front fringes gradually moved far enough south to be melted by the sun as rapidly as they advanced. Although the glaciers themselves continued to move, their fronts remained at the same point. Here large piles of drift or glacial till called terminal moraines were deposited. We see, too, that as the glaciers spread, deep gouging and scraping occurred and that natural basins deepened as the sun melted the front edges.

The advance and retreat of continental glaciers occurred at least twice, and possibly five or six times. After the last advance the Great Lakes were formed. The film explains that as the glaciers retreated, terminal moraines helped dam the water, thus filling the basins which had been made. The Mississippi River became the first outlet; and the Mohawk Valley and Hudson River allowed for additional drainage as more melting occurred. After the St. Lawrence Valley was uncovered and the sea had moved in as far as Lake Ontario, the land began to tilt and the sea waters drained away.

Between Lakes Erie and Ontario was a high vertical cliff over which water fell. Shale and sandy layers beneath the hard limestone covering have caused Niagara Falls to move back about seven miles in 30,000 years. (Although Professor Willard Libby, in his talk on Radiocarbon Dating, given just before this demonstration, made the point that his findings put the last glacial retreat back only about 11,000 years.) The cliff is still moving back at the rate of about five feet a year. (The application of simple arithmetic seems to corroborate Professor Libby's findings). The final sequence of the film reveals the physical characteristics of the vertical cliff at Niagara Falls and explains why in a few thousand years the Falls will become rapids.

After the film was shown, the students readily explained the formation of a glacier from the piling up of snow; the gouging of the old river valleys and the damming of them by the terminal moraines to form the Great Lakes basins. They easily explained, in response to a question about the present source of the Lakes water, that it comes not from river drainage, but largely from the fact that the Lakes have been scooped out to a depth below the water table, much as a well is dug and the water supply seeps in continuously from the water table.

Students understood, more clearly, the fact that the Chicago River in glacial times flowed into the Illinois and Mississippi Valleys; then later into Lake Michigan; and still later, through human engineering, into the Drainage Canal, the Illinois, and the Mississippi.

They were motivated to discuss the need for the St. Lawrence Seaway which would open the Great Lakes to ocean shipping.

One teacher in the audience wondered what would happen after Niagara Falls had cut back to Lake Erie. One of the students remembered the film explanation of the fact that when the Falls cuts back another few miles it will be in an area of harder rock and then will become a rapids.

The students indicated their mastery of the words, which they were alerted to before the film was shown, such as *Glacier*, *Moraine*, *Till* or *Drift*, *Gouge*, *Striae*, *Bedrock*, etc., by their correct use of them in their explanations. This is so because the words were defined for them in vital situations from their pictorial meanings on the screen, in other words, in functional situations.

I am sure, too, that, after this film experience, the students will be much more eager to pursue the subject of the Great Lakes not only in their textbooks, but in encyclopedias, atlases, and in other reference books, proving that films do not take the place of textbooks, but reenforce them in a unique and highly interesting fashion. Films, too, far from making things easier for the teacher, offer a real challenge to creative teaching, the students are motivated to ask far more, and far deeper questions than heretofore.

Teaching films offer educators a new technology in the area of communication to help them cope, not only with the greater quantity of learning in this age of stepped up technology, but also improve the quality of learning by their proved ability to provide increased retention.

Today there are hundreds of fine films in many areas of subject matter, which professional teachers are using with great skill.

ROY A. KROPP IS ELECTED TO BOARD OF CENCO CORP.

Roy A. Kropp, president of Kropp Forge Company and long a prominent figure in the forging industry and business circles, has been elected a member of the board of Cenco Corporation, Chicago, John T. Gossett, chairman, has announced.

Kropp has been president of Kropp Forge Company since 1936 when he succeeded his father, Charles A. Kropp. The firm was founded by his great grandfather in Annefors, Sweden, in 1837.

He is also president and director of Kropp Steel Company, Rockford, Ill., chairman and director of Kropp Forge Ordnance Company, Melvindale, Mich., subsidiaries of Kropp Forge Company, and chairman and a director of C. D. Gammon Company, Chicago trucking firm.

MNEMONICS GIVING APPROXIMATE VALUES OF PI

AARON L. BUCHMAN
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Occasions may arise when *pi* is to be expressed as a decimal correct to a certain number of digits. More than six such digits would occur only in a theoretical discussion of *pi*, as for practical purposes, fewer than six digits are sufficient. To aid the memory when more than six digits are required, mnemonics are often used. One such device consists of a sentence in which the number of letters in each word gives the value of the corresponding digit in the decimal expression for *pi*.

One such mnemonic, of unknown source, which the author has used in his classes for many years, gives *pi* to fifteen digits. It reads: How I want a drink, alcoholic of course, after the heavy chapters involving quantum mechanics.

In the leaflet, Palo Retort, the author found a little rhyme which gives *pi* correct to twelve digits.

See, I have a rhyme assisting
My feeble brain its tasks resisting.

Asked to write a jingle which would give *pi* correct to a greater number of digits, the author composed the following which gives *pi* correct to twenty four digits.

May I have a month, professor,
To figure these, you brain assessor?
Calculate, student, calculate now!
As the figuring gets longer,
My friend, hope you get stronger
And no figures, incorrect, allow.

"HOT LAB"—ATOMIC AGE TOOL

Nuclear scientists, who work daily with radioactive materials too "hot" to handle, have been able to solve many of their problems by using one of the most unique "tools" of the Atomic Age—the "Hot Laboratory."

One such group of scientists is at work in the Bettis Plant, Pittsburgh, Pa., of the Atomic Energy Commission. This plant is operated by the Westinghouse Atomic Power Division, which is engaged in two of the nation's atomic projects—construction of the atomic power plant for submarine U.S.S. *Nautilus*, and development of another nuclear reactor for a large vessel, such as an aircraft carrier. Both projects are being conducted for the U. S. Navy and the Atomic Energy Commission.

A major problem in the construction of nuclear reactors is that of handling radioactive materials during tests and laboratory analyses. For safety purposes, this testing is done almost completely by remote control in a building known as the "hot lab."

There are five "hot spots," or cells, in the Westinghouse "hot lab" and these are separated from the main working area by a thick, concrete and lead wall. In the cells themselves—each separated from the other by a thick steel wall—are testing devices designed especially for the lab's operations.

The inside of each cell is viewed through a 36-inch-thick window comprised of layers of plate glass separated by oil. Mechanical, claw-like "hands"—controlled from outside the cell—move radioactive objects into position for testing. A periscope-telescope arrangement enables scientists to examine specimens through a remotely controlled microscope.

CAN A SINGLE COURSE IN MATHEMATICS OR THE SCIENCES FILL THE DUAL OBJECTIVES OF GENERAL EDUCATION AND TRAINING OF FUTURE SPECIALISTS?*

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When the objectives of general education are mentioned one immediately wonders what is meant by general education and what its objectives are. Among educators it is certainly one of the most popular topics for discussion; volumes have been written on the subject, yet it is difficult, if not impossible, to isolate a clear-cut definition. In the junior college area there is increasingly greater emphasis being given to the terminal student with a concomitant de-emphasis on the college preparatory function. (At least on paper.) It is pointed out that, while the junior college was established to provide for the first two years of the four-year college, only about 20 to 25 per cent of junior college students actually continue to senior college. Koos states that the junior college "can no longer remain, what too many persons still think, 'just another place to get the first two years of college or university work'."[1]

A study of the literature clearly shows that leaders in junior college education are agreed on at least three major aims of the public junior college program. First the program should provide general education for *all* students. For many this may be terminal education; that is, the end of formal education. Second, the program should provide vocational or semi-professional education for those who expect to enter business or industry at the close of the junior college years. Third, the program should provide preparatory training for those who expect to continue study in the senior college.

Those interested in the mathematics program for the junior college, as well as others of the junior college family, face this trichotomy of objectives. If we lay aside the vocational objectives for the purpose of this discussion and consider the assigned topic of a single course for general education and specialists, there immediately arises at least two questions. First, what is the current program in junior college mathematics and how well does it fulfill the objectives of general education and training for future specialists? Second, what revisions, if any, should be made in the present mathematics curriculum better to realize the foregoing objectives?

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* Presented at the Junior College Group meeting of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, Chicago, November 29, 1952.

[1] Leonard Koos, "Points of Needed Curriculum Development," *Junior College Journal*, XVI (May 1946), 401–410.

In considering the first question it may be enlightening to review some studies of the mathematics offerings in public junior colleges.

In his excellent study on junior college mathematics Kidd[2] found that three-fourths of the 154 public junior colleges under consideration attempted to realize the aims of general education in mathematics through traditional high school courses and courses in business mathematics, while one-fourth of these institutions offered courses especially designed for general education. The mathematics offerings in the preparatory curricula were predominantly the traditional courses in college algebra, trigonometry, analytics, and the calculus, with major emphasis on pre-engineering. In fact 89 per cent of the schools in the study offered two years of pre-engineering mathematics.

In a study of mathematics offerings in fifty-two public junior colleges in California, Hammond[3] reported "Of the mathematics courses offered in the public junior colleges of California, 45 per cent are subjects of an engineering and science nature, 42 per cent are subjects taught in high school, 8 per cent relate to commerce and business, and 5 per cent relate to trade and industry." This study surely indicates that college preparatory subjects predominate the offerings while high school subjects are used to answer the general education needs.

In a survey of junior colleges in eight central states the writer[4] found only a smattering of mathematics courses other than the traditional sequence of college algebra, trigonometry, analytics, and the calculus. "About the best that could be said is that about 65 to 75 per cent of the courses are offered for about 25 to 33 per cent of the students."

The results of these three studies just cited seem to be typical of other investigations of the mathematics courses offered in public junior colleges. There seems to be little evidence of a well-planned curriculum in mathematics. There is considerable evidence that the offerings have drifted in the direction of imitating the traditional sequence of the freshman and sophomore years of the colleges with some courses especially designed for general education and high school courses frequently used in an attempt to answer the general education needs.

The Cooperative Committee on Science and Mathematics Teaching points out that the college courses are frequently pitched to the needs of future specialists to the neglect of those chiefly interested in

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[2] Kenneth Kidd, "Objectives of Mathematical Training in the Public Junior Colleges," *Contribution to Education No. 394* (Nashville, Tennessee, George Peabody College for Teachers, 1948).

[3] C. D. Hammond, "An Analysis of the Mathematics Courses Offered in the Public Junior Colleges of California," *Junior College Journal*, XX (Dec. 1949), 218–220.

[4] H. G. Ayre, "On the Status of Teaching Load, Salary, and Professional Preparation of Junior College Mathematics Teachers." *The Mathematics Teacher*, XLIII (Feb. 1950), 54–60.

general education. The Committee goes so far as to express the opinion that this is one of the main weaknesses of the science and mathematics programs in the colleges.

Before going further it seems logical to ask what mathematics has to contribute to the objectives of general education. Some of the contributions frequently mentioned in the literature upon which there seems to be considerable agreement are about as follows. The study of mathematics should promote the development of certain habits, attitudes, and appreciations, such as, systematic and independent thinking, good workmanship, appreciation of the role of mathematics in the development and growth of civilization, and the scientific approach to analyzing problem situations. Through the study of mathematics the student should gain certain understanding, knowledge, and concepts, such as, the nature of proof, the nature of the structure of mathematics, as a science and a mode of thought, the concept of number and our number system, the basic concepts and techniques of arithmetic, algebra, and trigonometry, with constant emphasis on the function concept. While a minimum of manipulative skills are essential it might be desirable to limit the skills that are pushed to a high level to the more elementary computations that have high value to the average citizen and place strong emphasis upon understandings, ideas, and appreciations. If listed in broad categories these objectives of mathematics for general education might be summarized as: 1. Development and understanding of the foundations of mathematics. 2. Development of meanings and appreciation. 3. Development of essential competencies.

There seems to be a great need for research better to identify the elements of mathematics having high value for general education.

If, as is claimed by many, the major purpose of the junior college is that of general education and not that of a prep school for specialists, then what justification is there for the present mathematics curriculum? Or how can one claim that general education is being served by lifting from the high school such courses as advanced algebra and solid geometry and transplanting them in the junior college? To the writer these are more or less rhetorical questions. However, it should not be implied that the traditional college preparatory sequence does not have general educational values. But, it is apparent that much of such values is being lost so far as the non-specialist is concerned because these values are not being emphasized and the student does not carry through on the long sequence of courses.

In considering the content of such a course in mathematics let it be assumed that junior college students are intelligent enough to *learn some mathematics* and they should not be limited to learning *about* mathematics, or to some of the courses in so-called practical mathe-

matics. The course should not be a superficial survey course, nor should it be a course in business training or bookkeeping. Perhaps some of the traditional topics usually included for the specialist should be omitted, or at least limited in scope. It would seem desirable to use the "broadfront" approach and include basic topics from many areas of mathematics. One approach to such a course would begin with a study of the development of our number system. The history of mathematics contains fascinating material on man's struggle to create the number system we more or less take for granted. It is good general education to know that our number system is the result of many extensions, certain limitations, and a long developmental process. Let the student appreciate some of the difficulties encountered in admitting fractions, negatives, zero, irrationals, and complex numbers. Let him understand what is meant by the closure postulate and how the invention of numbers "beyond" the positive integers made possible the system of numbers closed to the six fundamental operations. The idea of one-to-one correspondence between points in the plane and the complex numbers, and points in a plane and number pairs opens the avenue to some coordinate geometry. Furthermore, this approach leads the student in a natural way to the science of computation. It is, therefore, possible to provide needed review of arithmetic and algebra in a new and different setting.

The work in trigonometry might be approached through the functions of angles with solution of triangles limited, for the most part, to data suitable for slide rule solution thus affording opportunity for practical problems and emphasis on computation with approximate numbers.

A little introduction into geometry of three dimensions is easy of comprehension and intriguing. There are so many extensions from two dimensions to three dimensions that are so easy and natural that it seems a shame to deprive the student of this mathematical gem.

There is a question as to whether some calculus should be included or just how much. If it is introduced it seems that only the simplest concepts are appropriate such as average rate of change, instantaneous rate of change, the simplest integration to find the area under a curve and simple maximum and minimum problems. One of the guiding principles of teaching such a course should be to take plenty of time for assimilation. Consequently, there are many interesting and valuable topics that may have to be omitted. Some such topics on which there is not too much agreement among teachers are number theory, probability, theory of equations, problems in business and finance, topology and the like. It seems that regardless of the topics chosen the work would be greatly enhanced by frequent reference to their historical development.

Now, what are the arguments as regards a single course to fill the dual objectives of general education and specialized education? In the opinion of the writer the first step toward such a course would be to abandon the traditional "water tight compartments" of algebra, trigonometry, and analytical geometry for a unified freshman course which would serve as an introductory course for all students. Such a course would surely include among others, the foregoing topics mentioned as desirable for general education. It is exactly one-half century since Professor E. H. Moore gave his famous address making a plea for such a change. During the past fifty years many have agreed that mathematics cannot be artificially divided into compartments and at the same time show the unity and harmony which is rightfully a part of mathematics. At the Symposium on Teacher Education in Mathematics held at Madison, Wisconsin, August 26–30, 1952 the discussion group on pre-calculus mathematics agreed on the following points among others:

1. There are certain areas in the present pre-calculus program which should be deleted.
2. A much more significant program in pre-calculus mathematics could be presented through the medium of a thoughtfully integrated program than can be done through the traditionally compartmentalized program.

   A great deal of the beauty and significance of mathematics as a field of intellectual endeavor lies in its closely knit organization and interdependent structure. The compartmentalized program tends to neglect this important characteristic, in fact, it tends to build in the mind of immature learners an impression of complete absence of interrelationship. Such a situation contributes to inadequate learning and inability to build an appreciation of mathematics as a closely coordinated and significant body of concepts and skills which constitute a very important part of modern man's intellectual and physical universe.

The group suggested that the content for such a course might be organized under the six following areas.

1. Development and understanding of number systems
2. Development and understanding of the concept of function
3. Development and understanding of algebra as a language
4. Development and understanding of measurement
5. Development and understanding of coordinate systems
6. Development and understanding of the mechanics of critical thinking

Many mathematicians and educators have given their support to this type of course, many attempts have been made to construct texts to promote the cause, and many will agree that such a course may well provide mathematical knowledge and understanding not furnished in the traditional courses. However, there is still a reluctance on the part of many to give up the traditional. It may seem unfortunate that the teachers of this generation were students of the last generation. It takes effort to overcome inertia and it takes de-

termination and initiative to teach differently from the way one was taught.

After making the change to a unified course there are still many difficulties to be encountered in the attempt to satisfy this dual purpose: 1. The general student and the future specialist differ widely in mathematical aptitude and interest. 2. The two groups of students differ markedly in the amount of mathematical training prior to college entrance. 3. The size of the school presents programming difficulties. It would appear to the writer that those are the problems of much greater magnitude than the problem of a single course for the general student and the specialist. There seems to be nothing in the objectives or the subject matter for general education that is not just as desirable and worthy for the specialist, but the range of mathematical aptitude, interest and pre-college training make it difficult to serve all students in the same class. If it is safe to rely upon the statement that only 20 to 25 per cent of junior college students will proceed into senior college, then it seems that service would be rendered to more students by placing emphasis upon the general education aspect. The future specialist who has had three or even four years of high school mathematics, can profit by the broad approach to mathematics as a unified science. Their progress should be much faster than that of the terminal student. Their greater aptitude and interest for mathematics (if such exist) and their previous experiences in mathematics courses should prove valuable in achieving the desired competencies and the over-all comprehension of mathematics. The general student will, as a rule, need time to develop certain computational skills, he will surely need more time to assimilate new concepts, meanings, and techniques. The methods of teaching may be different, certainly there will be a substantial differential in the time element. Herein lies what is perhaps the greatest difficulty in teaching a single course for general education and special education.

In the larger schools where there are enough students of the future specialists type to form a separate class this would seem a desirable practice. The terminal students might well be given a test in such competencies as those given in the Check List of the Commission on Post War Plans of the National Council of Teachers of Mathematics. Thus it might be possible to ascertain whether students have sufficient command of the twenty-nine items in the "Check List" to proceed with the general course or whether they should begin with a preliminary basic course. However, there is some argument to the effect that a student's success in college is independent of the nature and content of his high school preparation. Although this argument claims to be based upon a very expensive and thorough piece of research, this writer is unable to see eye to eye with such conclusions.

This plan for the larger schools does not resolve the difficulties of the smaller schools. It should be pointed out, that, according to the *Junior College Directory 1952*, the enrollment in junior colleges ranges from fifteen students to 42,775 students. In many schools there may be enough students for only one class in pre-calculus mathematics. It would seem that if the percentage of future specialists holds approximately true for the smaller schools, then those students could be provided for by differentiated assignments and special help. With a small class it is not too difficult to offer two courses at the same hour. Where the high school and junior college are under the same system a basic preliminary course as previously mentioned might be offered for both high school and terminal junior college students. At the completion of this course the general student could take the unified course along with the future specialist.

By way of summary it can be stated that a review of the literature and the textbooks of the past fifty years shows that much thinking has been done and some progress has been made toward a unified pre-calculus course in mathematics for both mathematics majors and non-mathematics majors. There is much variety in these programs and a wide range of suggested subject matter. The prerequisites vary all the way from no high school mathematics to trigonometry and one and one-half to two years of high school algebra. It seems almost evident that students with such a wide range of preparation would be incompatible in the same class. However, this does not eliminate the possibility of a unified course where the future specialist can gain some concept of the possibilities of mathematics and the relation of its several branches which may not result from specialized courses. There is nothing in mathematics for general education that is not good for the future specialist. The greatest difficulty appears to be not in the possibility of a single course with dual objectives, but in its implementation with students of varying mathematical preparation, aptitudes, and interests.

More and more people are becoming convinced that technical competence in mathematics is possible without understanding the nature and significance of mathematics. Surely the future specialist as well as the general student should learn more about the foundations of mathematics and the structure of mathematics as a mode of thought. The teachers of science are facing a similar problem as is evidenced by the presence of the other two speakers on this program. The presence of the function concept in mathematics and the fact that mathematics is basic to research in science would seem to make the problem of the mathematics teachers easier of solution than that of the science teachers.

CAN A SINGLE COURSE IN SCIENCE FILL THE DUAL OBJECTIVES OF GENERAL EDUCATION AND TRAINING FUTURE SPECIALISTS?*

LOWELL C. WARNER
Chicago City Colleges, Wilson Branch

Careful consideration of all known facts and circumstances reveals a qualified answer of no. The next question might well be how can we then justify two courses—one for those who specialize and one for the student desiring to further his general education. The need for a particular specialized course has been accepted in the past.

In developing a philosophy of general education from the view point of science it is necessary to evaluate many problems which have evolved in all phases of public and private education. No one particular type of school is immune to the growing pains of a general education program. In the light of the past history of educational development many problems are recognized. What is more significant is that these problems are now admitted not only by educators, but by those engaged in purely academic fields of study. Unfortunately our progress in education has not kept pace with the changes in the economic and social life of the American Citizen.

Until recently achievement as a specialist was accepted as an ultimate educational goal. Now, while we are aware of the value of a specialized training program, we suddenly find that the specialist, whether he be an expert at performing some manual task or a delicate, intricate technique, is not sufficiently equipped to cope with the general problems which confront us today. As an example of this inadequacy we cite the wide variation of opinion regarding the distribution of information on atomic energy which exists among scientists whose integrity and professional status are well respected.

Our present system of higher education compromises by first giving the student a so-called liberal education, then a vocational or specialized training. However, it seems to be generally accepted that for a democracy to continue to be successful a great intelligence is required in the populace. In order to meet this requirement organized learning must be available to all. This may be interpreted to mean that each person should have available all the educational opportunities and responsibilities within his native capabilities. Four year colleges and universities contribute much toward meeting these objectives; however, their major role has been in the fields of specialized training rather than general education. While they will continue to

* Presented at the Junior College Group meeting of the Central Association of Science and **Mathematics** Teachers at the Edgewater Beach Hotel, Chicago, November 29, 1952.

expand their specialized training courses there remains the very difficult task of meeting the objectives of the increasingly larger number of students. There seems little doubt that it is not only desirable that we extend the facilities of general education beyond that of the secondary school but it is becoming increasingly necessary to do so.

In the past most students of higher learning have placed the emphasis on the economic value of education, but it is significant that industry and big business realize that their future success depends upon an intellectual aspect in which the population is educated for living. The continued success of industry is based upon an intelligent buying public. Even hardened businessmen who carefully weigh their taxable assets are aware that an intellectual public is a good investment not only for the present, but will insure a demand for a good product with adequate buying power to support a competitive market in the future.

The basis of American success and the prestige which the United States possesses is due to the American industrial dominance of which engineers and scientists are the foundation. Many of our United Nations' friends are quite envious of our economic and industrial achievements with less control and interference by government agencies than exist in their own countries. In order to prevent in this country such industrial decline as has occurred in Great Britain and Western Europe there must be a constant flow of scientists and engineers from our colleges and universities. Industry has recognized the importance of its supply of personnel and while we in the schools are not fully aware of its interests, nevertheless, its influence is having effect. Despite an increasing property tax, industry is encouraging competitive salary schedules and suggesting that school administrators consider teacher time distribution. Considerable of the teacher's time and effort has been expended on the average or below average student who has been estimated to make up about two-thirds of the college enrollment. Very little has been done for the one-third from which we obtain our leaders in government, industry, science and engineering.

Training for the professions is largely a responsibility for the four year college and university and seems likely to remain as such. The need for vocational training may be satisfied by special schools, junior colleges and extension programs. At the present time lack of facilities and inadequate staffing seem to prevent further expansion of vocational programs.

Whether a general course might serve a dual purpose would depend upon many factors whose influence is difficult to measure and whose importance is still more difficult to evaluate. The type of school, i.e.

technical, junior college, four year university, sectarian, magnitude of enrollment and the reputation and popularity of some particular department or members of the faculty influence the value of a general course.

The recognized purpose of a junior college is to serve the community which supports it. Let us see how well they may have succeeded.

1. The records of the students, reports of investigation committees on text books, equipment, library facilities and the professional and academic qualifications of the faculty indicate that this group of colleges is meeting the demands of the schools to which students have transferred for further study.

2. The rapid growth of the adult education program which offers extended opportunities to the community attests to the needs of the citizens of the locality which the college serves. As a further emphasis of the success in this field it is well to point out that the courses offered range from purely recreational development to those which are fully accredited academically.

3. The curriculum of the general education program in the junior college is the most difficult to establish, hence, the most controversial. There must be a desirable course of study to offer to those students who find only two years of higher education possible as well as offering preprofessional training.

The role of the physical sciences in this program is generally accepted even by those who in the past have placed it in a purely specialized field. The question is no longer should physics, chemistry, astronomy and geology be included in a curriculum of general education, but rather how much, how detailed, and how should it be presented. A teacher may measure, to some degree, the success of a course by determining whether the class as a whole has been stimulated sufficiently to pursue further study in the subject. While a positive reaction is a satisfaction to the teacher and indicates interest of the subject material and presentation, it is not a reliable criteria from which to judge a course in the curriculum of general education. The lack of maturity and flexibility of the youthful mind make the student's decision concerning an intelligent evaluation of subject matter questionable.

In the general education courses in the field of physical science with the equipment and facilities available in most colleges all lecture periods could be made a series of spectacular demonstrations. These experiments might illustrate basic scientific concepts, but would be a side show whose chief function would serve to entertain and interest the student. In contrast to this is a presentation of the factual scientific concepts with much less emphasis on dramatic

demonstrations. A compromise plan of presentation does not meet the aims or satisfy the objectives of a general course. It appears that the establishment of these objectives are a most difficult task. All phases of general course development are represented in our schools. I taught a course three years before I had any concrete ideas of the objectives to be reached by its offering. If was merely suggested that a certain text and topics be covered. Another course was offered almost 15 years without change. While we cannot hope to keep pace with the changing political, economic and social development, we cannot allow the curriculum to become stagnant. There must be some attempt of integration with the concepts of intelligent living. This means that a method must be employed to point out to the student the historical, practical, economic and political significance of physical phenomena included in the course.

The general content of many of the courses in the physical sciences in our colleges and universities has been handed down unchanged since the end of the Civil War. Fortunately an examination of the text books recently published for use in these courses reveals many new topics. This has been in the greater part, the result of the demand for emphasis on the practical application in the content of pre-professional courses and in methods of presentation. In general science teachers are products of a very specialized education and are reluctant to make major changes in the material covered in their courses. As a result they feel incompetent to apply their specializations to other branches of learning.

The visible successes have given modern science enormous prestige as an academic subject. The importance of science in a program of general education cannot be under-estimated. Yet it is frequently referred to as the worst taught of all subjects. Perhaps our inability to recognize our teaching weaknesses is that the hard discipline of the sciences has little to attract the masses and as a result this field suffers less than most others from an excessive number of mediocre students. Further, there is considerable controversy as to what actually constitutes good teaching.

A course for all students in the physical sciences to be successful as far as the student, the curriculum and the teacher are concerned must be built with many variable factors which do not themselves remain constant long enough to determine their influence on the course. For example, the regular beginning course in college physics is pitched too high for the student in the general program. He does not have adequate preparation for further work in the subject nor is he interested in the details so necessary for the engineer or scientist. To further emphasize, many physics departments have planned courses for the pre-medic student differing in mathematical detail and

theoretical approach from the regular course. Along this line of thought it is interesting to note that the medical profession recommends additional physics courses if at all possible, particularly in the atomic and electronic fields. Much technological information is out of date within a few years' time. However, the basic fundamentals remain unchanged. To the professional scientist most important are the procedures for applying basic fundamentals to new problems, techniques and the promotion of individual ingenuity.

A course whose objective is general education has most nearly fulfilled its educational objective when the student is able to pursue the cultural aspect of life, judge the economic and political impacts on his community and the world, and found a spiritual inspiration resulting from the refinement and training inspired and guided by his contact with the college.

We cannot then in a single course meet the demands of the specialists and requirements of general education. We recognize the importance of both. We have done little enough for our more rapid learners as we need the maximum output of the best minds in every specialized field. There is a possibility that there has been a great tendency to level off the learning opportunities of our better students in the lower grades and colleges. Let us recognize the individual scholar and pamper less the potential impossible scientists. Idealism cannot maintain our strength in the world. Self-preservation and world leadership is at present paramount—not sacrificial idealism. Let us not make the fatal error of allowing our recognized value of general education and the enthusiasm of entering a new educational phase run away with our better judgment. We spend little enough money on our schools. We can afford to provide a well educated people and at the same time provide the opportunity for specialized training. We can ill afford not to.

RARE EARTHS ON LARGE SCALE AVAILABLE BY NEW TECHNIQUE

Large-scale production of pure rare earths, 15 hard-to-separate metallic elements, is promised through the development of a new extraction method at the Argonne National Laboratory.

The purity of the final product is not as great as by the ion exchange method, but the new process works much faster. The extraction method depends upon careful control of the strength and amounts of nitric acid and tributyl phosphate used.

A combination of the solvent extraction method and the ion exchange method would produce, for the first time, large quantities of high-purity rare earth elements, Dr. D. F. Peppard of the laboratory here suggests. Co-workers in development of the new method were J. P. Faris, P. R. Gray and G. W. Mason.

SIMPLE EXPERIMENTS IN PHOTOMETRY

Franklin B. Wells and David S. Kilbourn
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The object of this investigation was to provide a simple, relatively inexpensive and reasonably accurate method of determining and comparing the luminous intensities of common sources of illumination which emit light of different colors. The present investigation was limited to sources emitting light which varied in color from substantially white to yellow-orange, but it may be extended readily to sources of other colors with the aid of additional tables similar to those included below. Since the method employed depends upon the well known use of color filters as described by Hardy and Perrin,[1] Forsythe[2] and other authors of standard works dealing with photometry, it is obvious that it may be applied only to those cases where the filtered light source emits a substantially continuous spectrum.

As is shown below, the use of colored cellophane filters makes possible the comparison and standardization of light sources of different color with the common box photometer. The filter material used was Dennison's non-moisture proof Gift Wrapping made from du-Pont Cellophane in yellow (amber*) and orange (heliotrope*). Samples obtained from two different localities and directly from the duPont Co. were checked against each other and found to possess identical characteristics of light transmission with the equipment used, and it was assumed, therefore, that this material is of sufficient uniformity to allow for its use as light filters. Issuance by the duPont Co. of a table of light transmission characteristics of colored cellophanes is, in itself, an indication of the uniformity of the material.

The data in Table I were obtained by the use of a 40 watt tungsten filament lamp operating at a current flow of 327.5 milliamp and a potential drop across its terminals of 110 volts. The data in Table II were obtained by the use of a newly standardized, 20.4 candle, carbon filament lamp operating at a current flow of 500 milliamp and a potential drop across its terminals of 110 volts. As expected, the use of direct current and of 60 cycle alternating current gave identical results so that the type of current used is not designated. A photocell, equipped by the manufacturer with a filter causing its response to match that of the human eye, in series with the required 200 ohm resistance was connected to a microammeter and placed at such dis-

[1] Hardy and Perrin, "The Principles of Optics."
[2] Forsythe, "Measurement of Radiant Energy."
* Samples obtained from the duPont Co. bore the designations "amber" and "heliotrope," and these designations are used throughout. Such samples and a table of their characteristics of light transmission were obtained through the courtesy of Dr. Edgar W. Spanagel of the Cellophane Division.

tances from the unfiltered source that its output was 200, 300, 400, and 500 microamp respectively. At each of these distances, various combinations of cellophane filters were interposed between the source

TABLE I. PERCENTAGE TRANSMISSION OF LIGHT FROM INTERNALLY FROSTED TUNGSTEN FILAMENT LAMPS THROUGH CELLOPHANE FILTERS

		Number of Heliotrope Filters Used						
		0	1	2	3	4	5	6
Number of Amber Filters Used	0	100.0	78.5	67.5	58.0	50.5	45.5	37.5
	1	88.0	75.0	63.0	54.0	46.5	40.0	
	2	82.0	67.5	58.5	50.0	43.0		
	3	76.0	63.0	54.0	46.0			
	4	71.0	58.5	50.5				
	5	65.5	54.5					
	6	61.0						

TABLE II. PERCENTAGE TRANSMISSION OF LIGHT FROM STANDARD CARBON FILAMENT LAMPS THROUGH CELLOPHANE FILTERS

		Number of Heliotrope Filters Used						
		0	1	2	3	4	5	6
Number of Amber Filters Used	0	100.0	80.5	69.5	60.5	52.0	45.5	39.5
	1	90.5	75.0	65.0	56.0	48.5	42.0	
	2	84.0	69.5	60.0	52.0	45.0		
	3	78.0	64.5	55.5	48.0			
	4	72.5	60.0	51.5				
	5	67.5	56.0					
	6	63.0						

All values in the above tables are to the nearest half per cent.

and the photocell whose output was recorded in each case. These readings were then converted to per cent light transmission. In this form the results obtained with any given filter combination were

found to be the same for the same light source regardless of the arbitrarily chosen distance between the source and the photocell.

A separate series of determinations was made in the same way with the 40 watt lamp operating at a current flow of 342.3 milliamp and a potential drop across its terminals of 116 volts. Results were obtained which were identical with the original ones. This indicated that the slight color change caused by the increased power consumption was not great enough to be detected by the moderately sensitive equipment used.

Results of further determinations using another 40 watt and a 60 watt lamp, both with tungsten filaments, were identical with those from the original 40 watt lamp, and the use of two other newly standardized carbon filament lamps of 16.6 and 18.7 candles respectively produced results which duplicated those obtained with the original 20.4 candle lamp.

The results so obtained and calculated to the nearest one-half per cent were then compiled in Tables I and II. It will be seen from these tables that the filters transmit about two per cent more of the yellow light from the 20.4 candle lamp than is the case for the substantially white light from the tungsten filament lamp. An attempt was made to set up similar tables for a candle and a small kerosene lamp, but these sources were too feeble to yield easily reproducible results with the photocell employed. However, indirect measurements have indicated clearly that about three per cent more of the very yellow candle light and about four per cent more of the orange-yellow light from a kerosene lamp is transmitted than is the case for the light from a tungsten filament lamp. Actually, then, only Table I is needed with corrections of 2, 3, and 4 per cent as the occasion requires. The filters must be smooth and perpendicular to the light ray which passes from the center of the source to the center of the photocell. Wrinkles and tilting to more than four degrees from the perpendicular both cause small but significant errors in the readings.

A few examples, some of which were used initially in the determination of the light transmission characteristics of a candle and a small kerosene lamp, will serve to illustrate the use of the tables. In the examples where the 40 watt and the 20.4 candle lamps are used, the current flow was 327.5 and 500 milliamp respectively. The standard candle mentioned in some of the examples was made, as recommended by the A.P.H.A. and the U.S. Geol. Survey, of spermacetti and beeswax in such a way that it had an average luminous intensity of one international candle while consuming an average of 120 grains of wax per hour. Such candles may be obtained from most scientific equipment dealers. A box photometer was used in all cases.

The 40 watt lamp was standardized against the 20.4 candle lamp using two amber filters in conjunction with the 40 watt lamp to produce a good color match on the ground glass screen of the photometer eye piece, and balanced illumination was obtained at 53.2 cm. from the 40 watt lamp and 46.8 cm. from the 20.4 candle lamp. Using the the inverse square law, the effective intensity of the 40 watt lamp was determined as being 26.4 candles. Table I shows that the two amber filters transmit 82 per cent of the incident light so that the true intensity of the lamp was 32.1 candles. Since the lamp was consuming 39.7 watts, the efficiency was 10.1 lumens per watt, a value almost identical with the known mean efficiency of such a lamp.

In another case, the 20.4 candle lamp with two amber filters was balanced against a standard candle at 80.5 cm. from the lamp and 19.5 cm. from the candle. Based on unity for the candle, the effective intensity of the lamp was 17.1 candles. From Table II it is seen that 84 per cent of the incident light from the lamp was transmitted so that its true intensity became 20.3 candles. Conversely, based on 20.4 candles, the effective luminous intensity of the lamp was 17.1 candles and the intensity of the candle 1.01 candles. Although Forsythe[2] and others state that the minimum distance from source to screen must be 10 to 15 times the maximum dimension of the source for the inverse square law to be applicable, no difficulty was experienced in this latter example. However, it was found to be impossible to obtain reproducible results when attempting to balance the standard candle against the 40 watt lamp, one amber filter being used with the candle and one heliotrope filter with the lamp. In spite of the inability to obtain reproducible readings, it is of interest to note that an average of 25 readings placed the screen at 83.9 cm. from the lamp and 16.1 cm. from the candle. Using calculations similar to those illustrated above, the intensity of the lamp was found to be 31.5 candles based on unity for the candle, and conversely, the intensity of the candle was 1.02 candles based on 32.1 candles for the lamp.

In a third case, balanced illumination occurred at 69.6 cm. from the 20.4 candle lamp in conjunction with one heliotrope filter and 30.4 cm. from a small kerosene lamp in conjunction with one amber filter. By calculations similar to those above, the luminous intensity of the kerosene lamp was found to be 3.4 candles.

In the fourth example which was carried out immediately after the example above without changing the wick setting of the kerosene lamp, balanced illumination was obtained at 66.1 cm. from the kerosene lamp in conjunction with one amber filter and 33.9 cm. from the standard candle in conjunction with one heliotrope filter. Based on unity for the lamp, the luminous intensity of the kerosene lamp was found to be 3.38 candles.

It was concluded from the examples cited above, and others similar thereto, that the luminous intensities of common sources of illumination which emit light varying in color from very nearly white to orange-yellow may be compared by the use of a common box photometer or simple optical bench with the aid of the included tables and the noted corrections thereto when appropriately colored cellophane filters are used for the purpose of obtaining a good color match between the two sources of illumination, providing that the filtered source or sources emit light with a substantially continuous spectrum.

NEW LOCOMOTIVE'S WHEELS MOVE SIDEWAYS

A gas turbine locomotive with wheels that not only turn to negotiate curves but also move from side to side under the cab for smoother riding, was reported in New York City, recently by engineers of the Westinghouse Electric Corporation.

The experimental locomotive, which has completed more than 60,000 miles of operation on six railroads, was described in a paper presented before the American Society of Mechanical Engineers by Charles Kerr, Jr. Co-authors of the paper are T. J. Putz and T. L. Weybrew.

"This locomotive is the first gas turbine passenger unit to be operated in the United States," Mr. Kerr declared. "It is an eight-axle, single-unit locomotive, weighing 247 tons, powered by two 2,000-horsepower gas turbines with an electric transmission."

The Westinghouse-Baldwin locomotive, he said, has a maximum speed of 100 miles an hour. During its test runs on the Pennsylvania Railroad, it pulled trains averaging 26 to 29 cars in length.

The radically new type of locomotive running gear consists of four two-axle trucks. Each of these trucks not only swivels in the usual fashion when rounding a curve, but also moves laterally under the cab of the locomotive, Mr. Kerr explained. A roller carriage is attached to each truck and the cab of the engine rests on the rollers of the four carriages, thus permitting lateral motion.

"Universally favorable comment has been received on the smooth riding and good tracking features of the locomotive," the Westinghouse engineer said. "Except for one minor change in the stiffness of a spring, no troubles with the novel running gear have been experienced," he added.

During most of its test runs, the gas turbine was operated on low grade, residual fuel oils.

"Fuel consumption in gallons," the speaker said, "has been approximately twice that of diesel locomotives in the same service." But he added: "The price paid for residual oils has varied from 3.5 cents per gallon up, depending upon location, against diesel oil prices of 8.6 cents per gallon up. Lubricating oil consumption has been practically nil.

"This locomotive is the product of an extensive development program which included first the design, construction and test of a gas turbine power plant suitable for locomotive service, followed by the construction of the locomotive, and finally road service to determine the adequacy of the design," the Westinghouse engineer reported. He concluded:

"Modern diesel locomotives accumulate high mileage records which, over the life of the locomotives, may run into the millions. By these standards, the accumulated experience on this locomotive is relatively low. However, we feel that the experience secured has been quite extensive. We have learned where changes were necessary, and in many instances, have seen our innovations prove to be very successful. We also feel that we have accomplished the purpose intended; namely, securing road experience with this type of motive power."

THE TRISECTION OF THE AREA OF A CIRCLE

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This is an interesting problem not often dealt with in the text-books.

Three radii at angles of 120° with one another afford the simplest solution of this problem.

Another solution whose results are shown in Fig. 1 requires the use of the calculus and tables and approximate methods.

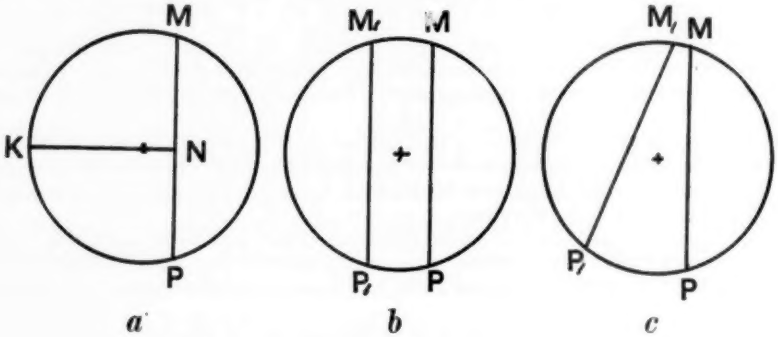

FIG. 1

In Fig. 1 (a) after cutting off one-third of the area of the circle by the chord MP the remainder is bisected by a portion KN of the diameter at right angles to MP. In Fig. (b) an equal chord M_1P_1 is drawn parallel to MP. In Fig. 1 (c) the equal chords MP, M_1P_1 are shown inclined to each other but not cutting each other.

Let R = radius of the circle and H = height NL of the segment $MLPN$ (Fig. 1 (a)). Geometry or Calculus (Similar to that below) shows that the area $MLPN = R^2 \cos^{-1}(R-H)/R-(R-H)(2RH-H^2)^{1/2}$. This expression may be put equal to $\pi R^2/3$ and solved for H.

The solution is not easy so I give another approach to the search for the position of N.

In Fig. 2 on the supposition that the position of N is found, the area $LNM = \pi R^2/6$. The area of the quadrant $LOQ = \pi R^2/4$. Therefore area of figure $ONMQ = \pi R^2/12$. This area may be obtained by summing the areas of all vertical cells like ST between OQ and NM. Take axes of x and y horizontally and vertically respectively through O. Let $OT = x$ and width of cell $= dx$. Its height is y and area of cell $ST = ydx$, and area $ONMQ = \int_O^{ON} ydx$.

It is better to change to a new variable θ where $\theta = \angle SOY$. Its final value $\theta_1 = \angle MOY$. We shall seek the value of θ_1 and then put $R \sin \theta_1 = ON$.

In terms of the new variable

$$x=R\sin\theta,\qquad y=R\cos\theta,\qquad dx=R\cos\theta d\theta.$$

Therefore

$$\text{area } ONMQ=\int_0^{\theta_1}(R\cos\theta)(R\cos\theta)d\theta.$$

$$\text{This}=R^2\int_0^{\theta_1}\cos^2\theta d\theta=\frac{R^2}{2}\int_0^{\theta_1}(1+\cos 2\theta)d\theta=\frac{R^2}{2}\left(\theta+\frac{\sin 2\theta}{2}\right)_0^{\theta_1}$$

$$=\frac{R^2}{2}\left(\theta_1+\frac{1}{2}\sin 2\theta_1\right).$$

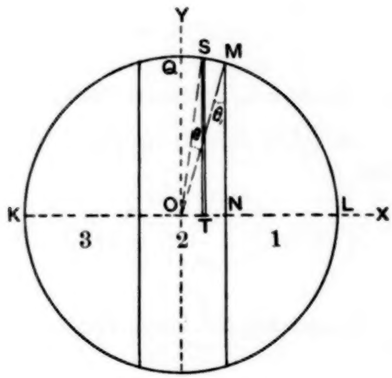

FIG. 2

This must equal one-twelfth of the area of the circle. Therefore

$$\frac{R^2}{2}\left(\theta_1+\frac{1}{2}\sin 2\theta_1\right)=\frac{\pi R^2}{12}$$

or

$$\theta_1+\frac{1}{2}\sin 2\theta_1=\frac{\pi}{6}\cdot$$

$2\theta_1$ is obviously about 30°, therefore expand $\sin 2\theta_1$ in powers of θ_1 and we get

$$\theta_1+\frac{1}{2}\left\{2\theta_1-\frac{(2\theta_1)^3}{3!}+\frac{(2\theta_1)^5}{5!}+\cdots\right\}=\frac{\pi}{6}$$

or

$$2\theta_1-\frac{4}{6}\theta_1^3+\frac{16}{120}\theta_1^5\cdots=\frac{\pi}{6}=0.52360$$

or

$$\theta_1-\frac{1}{3}\theta_1^3+\frac{1}{15}\theta_1^5\cdots=\frac{\pi}{12}=0.26180.$$

As a first approximation neglect the terms in θ_1^3 and θ_1^5 and we get $\theta_1=0.2618$ radian.

As a second approximation neglect the θ_1^5 term and substitute this value of θ_1 in the θ_1^3 term

$$\therefore\quad \theta_1-\frac{1}{3}(0.2618)^3=0.26180$$

or

$$\theta_1-\frac{1}{3}(0.01794)=0.26180$$

$$\theta_1=0.26180+0.00598=0.26778 \text{ radian.}$$

As a third approximation substitute this value of θ_1 in both the θ_1^3 and θ_1^5 terms. We get

$$\theta_1-\frac{1}{3}(0.26778)^3+\frac{1}{15}(0.26778)^5=0.26180$$

$$\theta_1-\frac{1}{3}(0.019201)+\frac{1}{15}(0.00138)=0.26180$$

$$\theta_1-0.00640+0.00009=0.26180$$

or

$$\theta_1=0.26811.$$

As a fourth approximation substitute this value of θ_1 in the θ_1^3 and θ_1^5 terms. We get

$$\theta_1-\frac{1}{3}(0.26811)^3+\frac{1}{15}(0.26811)^5=0.26180$$

$$\theta_1-\frac{1}{3}(0.019272)+\frac{1}{15}(0.00139)=0.26180$$

$$\theta_1-0.006424+0.00009=0.26180$$

$$\theta_1=0.26813=15°22'$$

$$\sin\theta_1=0.2649 \qquad \therefore\quad ON=0.2649R.$$

and if $R=8.000$ cm. $ON=2.119$ cm. $=2.12$ cm. near enough for our purpose. Cos $\theta_1=0.9643$ $\therefore$ $MP=2R(0.9643)$ and if $R=8.000$ cm. $MP=15.43$ cm.

Another way of solving the problem is to use a table of sines in terms of radians and search for a solution of the original equation,

$$\theta_1+\frac{1}{2}\sin 2\theta_1=\frac{\pi}{6}=0.5236.$$

We soon find θ is nearly 0.27 and the last steps of the search are given below.

θ_1	0.270	0.265	0.268	0.2681
$2\theta_1$	0.540	0.530	0.536	0.5362
$\sin 2\theta_1$	0.5141	0.5055	0.5107	0.5109
$\frac{1}{2}\sin 2\theta_1$	0.2571	0.2528	0.2554	0.2555
$\theta_1+\frac{1}{2}\sin 2\theta_1$	0.5271	0.5178	0.5234	0.5236

Therefore $\theta_1=0.2681$ rad., as before.

A more accurate value could, of course, be obtained but the above is sufficient for our purpose. Thus the problem is solved.

Elementary students may try this problem on squared paper. I use cm-squared paper and Fig. 3 shows the upper right quadrant of a circle of 8 cm. radius divided into vertical cells of width 1 cm. Their areas are numerically equal to their mid-ordinates which (read from the paper) are, from right to left, 2.6, 4.6, 5.8, 6.6, 7.2, 7.6, 7.9, 8.0. To find the position of N we start from the right and count in cells and a position of a cell until we get an area of $(\pi.8^2)/6=33.51$ cm². We find $2.7+4.7+5.8+6.6+7.2=26.8$ cm². We therefore need 6.7 cm² in addition and so we take from the 7.6 cm. cell a width of 6.7/7.6 or 0.88 cm. giving a total for LN of 5.88 cm. or $ON=2.12$ cm. a near approach to the 2.119 cm. obtained above.

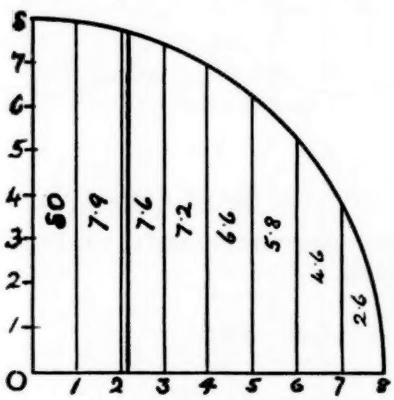

Fig. 3

The same processes may be extended to higher dissections using symmetry to complete the number of chords required.

Division into 4 Equal Parts

Leaving out the obvious method of 4 equal quadrants Fig. (4c) the chord between segments (1) and (2) in Fig. (4a) must be drawn to satisfy the equation

$$\theta_1+\frac{1}{2}\sin 2\theta_1=\frac{\pi}{2}-\frac{\pi}{4}$$

whence the distance of the chord from the centre $=R\times 0.404$. The chord between segments (2) and (3) is a diameter. Fig. (4b) is an obvious variant.

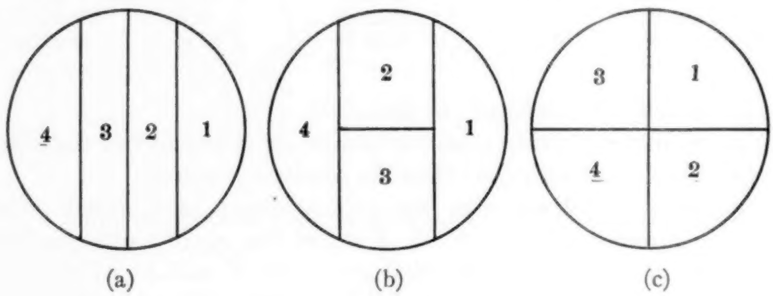

Fig. 4

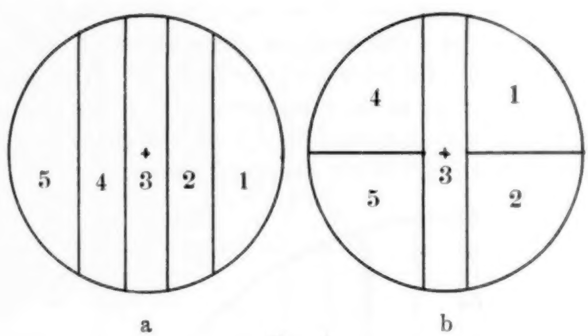

Fig. 5

Division into 5 Equal Parts

The chord between segments (1) and (2) of Fig. (5a) must be drawn to satisfy the equation

$$\theta_1+\frac{1}{2}\sin 2\theta_1=\frac{\pi}{2}-\frac{\pi}{5}$$

and the chord between segments (2) and (3) to satisfy

$$\theta_2+\frac{1}{2}\sin 2\theta_2=\frac{\pi}{2}-\frac{2\pi}{5}\cdot$$

Their distances from the centre are $R\times0.492$ and $R\times0.158$ respectively. An obvious variation of Fig. (5a) is shown in Fig. (5b) where, by symmetry, a horizontal diameter serves a useful purpose.

Division into 6 Equal Parts

The chord between segments (1) and (2) of Fig. (6a) satisfies

$$\theta_1+\frac{1}{2}\sin 2\theta_1=\frac{\pi}{2}=\frac{\pi}{6}-\frac{\pi}{3}\cdot$$

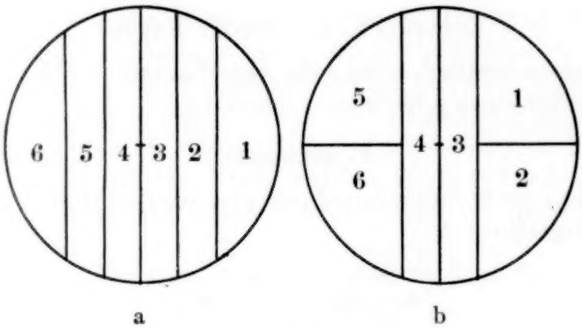

Fig. 6

The chord between segments (2) and (3) of Fig. (6a) satisfies

$$\theta_2+\frac{1}{2}\sin 2\theta_2=\frac{\pi}{2}-\frac{2\pi}{6}=\frac{\pi}{6}\cdot$$

It is the chord (1, 2) of Fig. 2. The chord between segments (3) and (4) is a diameter. The distances of these chords from the centre are $R\times0.553$, $R\times0.265$ and $R\times0$ respectively. Another alternative not illustrated is to take the figure for three equal parts Fig. 1b and draw a horizontal diameter thus obtaining six equal parts.

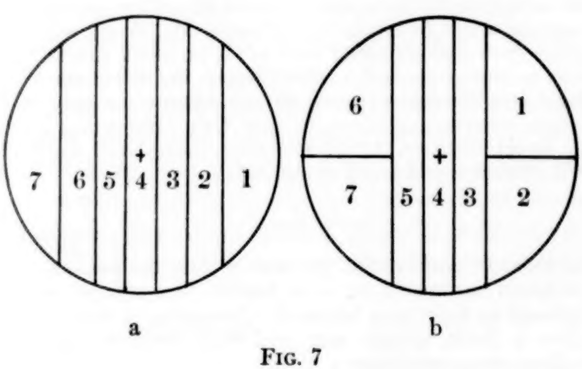

Fig. 7

Division into 7 Equal Parts (Fig. 7)

The equations for the θ's of the chords between segments (1) and (2), segments (2) and (3), segments (3) and (4) of Fig. (7a) are

$$\theta+\frac{1}{2}\sin 2\theta=\frac{5\pi}{14},\quad \frac{3\pi}{14},\quad \frac{\pi}{14}$$

respectively and the solutions for the distances from the centre are $R\times 0.598$, $R\times 0.344$ and $R\times 0.112$ respectively.

A variation of Fig. (7a) is shown in Fig. (7b).

Division into 8 Equal Parts

The obvious method is to take the diagram for 4 equal parts Fig. (4a) and to draw a horizontal diameter.

In General

To divide a circle into n equal parts by parallel chords we have to solve the equations

$$\theta+\frac{1}{2}\sin 2\theta=\frac{\pi}{2}-m\frac{\pi}{n}$$

where m has the values $1, 2, 3, \cdots, n/2$ if n is even and $1, 2, 3, \cdots, (n-1)/2$ if n is odd.

Note: I use Barlow's Tables of Squares, Cubes, etc. (E. and F. N. Shon, London and Chemical Publishing Company, New York) for the numerical values of the powers of numbers and Milne-Thomson and Comrie's Standard Four-Figure Mathematical Tables (Macmillan and Co., London) for the trigonometrical functions of the angles expressed in radians.

TWO BILLION DOLLARS INVESTED IN IRRIGATION

Twenty-five million acres of American soil are now under irrigation, served by canals that would stretch five and a half times around the globe, Ivan D. Woods U. S. Department of Agriculture, told the American Society of Agricultural Engineers.

The Federal government alone has invested $2 billion in irrigation projects, roughly the amount spent to create the A-bomb, Mr. Wood said. Gross returns so far from crops grown on irrigated land are over seven times this amount, he said, amounting to more than half a billion dollars in 1950 alone.

Irrigated land now furnishes nearly all our domestic supply of apricots, almonds, dates, figs, prunes, and olives, he said. Other important irrigation crops; lettuce, 90%; sweet cherries, 85%; avocados, pears and cantaloupes, 75%; asparagus, 65%; peaches and truck crops, 50%.

Flexible hardboard, made in $\frac{1}{8}$-, $\frac{3}{16}$- and $\frac{1}{4}$-inch thicknesses, sells competitively with standard hardboard yet is so flexible that a small strip can be bent into a circle almost as tight as a hatband. Consisting of wood fibers that have been blown into a thick, spongy mat and then pressed, the board has high strength and dimensional stability.

A HIGH SCHOOL SCIENCE ACTIVITY PROGRAM

J. O. Derrick
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Science, of all the high school areas of learning, contains material of greater appeal to teenagers than any other area except possibly music and the headlines of sports. Teenagers are naturally curious about what goes on around them. Yet, most science teachers have seen classes start in the fall with enthusiasm that later lags. As interest decreases, sometimes one or two of the most enthusiastic students become problems or even drop out of school.

The first tendency is to blame the child. The fault could easily lie with the teacher, who might have made so simple a mistake as adhering too closely to the "book", when a few experiments or demonstrations *by the students*, even without much formal equipment, would have maintained interest and solved the problem of the "problem child."

Good science clubs have a definite place in such situations. They can be used to stimulate interest, to develop initiative, to build mutual understanding between students and teacher, and to give an opportunity for the superior students to do worthwhile work while the slower ones learn the minimum fundamentals. These objectives can be attained in class, but the informal atmosphere of a club lends itself to easier accomplishment in some of these areas.

Science clubs may be specialized and center interest, for instance, on radio or photography; or they may be of the general type, such as the chemistry, the physics, or the biology club. In small schools there may be just one club covering all the sciences. The general type of club is more desirable except possibly in the large high school where there may be a specialized type for advanced students. The author thinks it essential not to have more than about twenty students in each club. If more than that number desire science club work, the club should be divided according to the interests and the scholastic standing of the students.

Club programs may vary with the interests of the sponsor and the students or with the type of school and community in which the club is located. Certainly the science club should center its activities around the community first. In a community school the science club should play a very important part, but a different one from that in the old type school where the curriculum is almost wholly college preparatory.

Some ideas for programs are:

1. Motion pictures and slides. This is a lazy type of program as far as the

student is concerned, unless he makes the movies and slides. It should be seldom used. It does not give enough student participation.

2. Trips. This type of program is easy on the student, but if properly done, difficult for the teacher.
3. Demonstrations of original experiments or of those copied from scientific literature. The author is very much in favor of this type of program.
4. Spelling matches, cross-word puzzles, and other games involving scientific information, such as formulas, scientific names, or great men of science.
5. Special speakers. They should be good, and should be included on the program only once or twice a year. The students should prepare and participate in most of the programs. Under the right kind of guidance an atmosphere can be built in a school that will cause students to like doing things themselves.
6. Vocational guidance programs. A panel of guest speakers representing the leading scientific professions of the community might be invited as participants. To them students might direct appropriate, prepared questions as to requirements for success. The author saw one guidance program successfully worked out around a number of college catalogs from technical schools dealing with entrance requirements and other features of the colleges.
7. Famous birthdays.
8. One or two socials a year.
9. Programs based on seasons or special holidays. One of the best programs the author ever attended was built around "Christmas Evergreens."
10. Natural scientific wonders. Students might be encouraged to collect post cards and snapshots while on their vacations. An opaque projector or other means might be used to show the pictures while appropriate talks were made dealing with topics such as glacial action, old and new streams and mountains, or succession of plant communities in an abandoned field or pond.
11. Exchange programs with neighboring schools. Schools swap athletic contests. Why not other features of the educational program?
12. Sponsor one big idea each year.
    a. Open house. This kind of program gives an excellent chance for good public relations. It exhibits what is good and gives the school a chance to remind parents of what is needed.
    b. Bulletin board or display case for student projects, such as "The element of the week."
    c. A district science contest or the Westinghouse scholarship contest.
    d. Writing of letters by students in which they request free materials. Students get a kick out of writing for and receiving such samples. The letters should be signed by both the student writer and the teacher, and the school address should be given, preferably on stationery carrying the school letterhead.
    e. Participation by the club in the community summer recreation program. Science students might teach others how to develop pictures, do taxidermy, and follow many other worthwhile hobbies.

There are many good references that will help the beginning teacher and students to get started:

1. Sponsor Handbook, Science Service, 1719 N Street, N.W., Washington 6, D. C. Free to club sponsors. $1.00 to others. This is the best science club reference the author knows. It covers the whole field from how to organize and what to name the club to suggestions for programs and where to get the material for programs.
2. Bulletin No. 2, "Films on Chemical Subjects," American Chemical Society, 1155 Sixteenth Street, N.W., Washington 6, D. C. Price 50¢.

3. "Free and Inexpensive Learning Materials," Division of Field Surveys, George Peabody College for Teachers, Nashville, Tennessee. Price 50¢.
4. Two bibliographies by the author dealing with specific programs on chemical subjects: "One Hundred High School Chemistry Projects," *Journal of Chemical Education* (17, 492, Oct., 1940), and "A Bibliography of Chemistry Projects and Demonstrations, 1940–49," *Journal of Chemical Education* (27, 562, Oct., 1950). If this magazine is not in the school library, a near-by college will be glad for teachers and students to visit it, use the library and make notes on the above projects. Visiting such a library would be valuable experience within itself and in an hour or so enough projects could be outlined for several years.
5. "Discovery Problems in Chemistry," Eckert, Lyons and Strevell, College Entrance Book Company, New York, has an excellent unit on "Applying Chemistry to Your Daily Life." It covers such topics as testing for nutrients, preservatives and adulterants in foods; soil analysis; scouring powders; instructions for dyeing, removal of spots and stains; preparation of paints and lacquers, cosmetics, toilet articles, etc.
6. "After Dinner Science," Sweezey, McGraw-Hill, New York. $3.00.
7. "Science Experiences with Ten-Cent Store Equipment," International Textbook Company, Scranton, Penn. $1.60.
8. "Fun with Chemistry," Freeman, Random House, New York. $1.25. Household chemicals are used for the experiments.

The future, it has been said, belongs to youth and to science. Through science clubs the teacher can give the organization and supervision that might prove helpful to the modern Hall, Edison, Moseley, Faraday, or Pasteur. What greater privilege can the teacher have than to give these future scientists a helping hand and to treat them with encouragement and sympathy, remembering that the "frontiers of the future are in the minds" of these students?

MEEK INHERIT THE EARTH

Big things can evolve out of little ones, but not little things out of big ones. The whole course of evolutionary history is littered with examples of developmental lines of animals and plants that started small, grew big, then huge, and then—died. Faced with changed and adverse conditions, they apparently could not contract the scale of their operations to weather the storm. They could only go into involuntary bankruptcy and pass out of the picture.

It was so with the dinosaurs. The earliest reptiles, in the age that succeeded the lush days of the coal era, were moderate-sized beasts. The biggest of them did not outrank modern crocodiles or the giant tortoises of the Galapagos. In succeeding geologic periods, one reptilian line, the dinosaurs, began to take on size; first as big as a horse, finally as big as a house.

Then came one of the world's periods of major geologic change—a revolution—and down went the dinosaurs. The reptiles that survived and now possess their modest share of the earth were the less ambitious, less grandiose orders—lizards, tortoises and turtles, crocodilians, and the later-appearing snakes.

The same is true of the giant plants that lived in the coal age. They were, some of them, relatives of the common horsetail rushes that now grow along railway embankments and in moist sandy soil. They aspired to great heights, developed into things as big as the giant cacti of our Southwest.

But when geologic hard times came they couldn't "take it," and so passed out, leaving their share of the picture to their poor relations, the smaller horsetails, that somehow managed to struggle through not only those hard times but all that followed, and are still with us.

MOTIVATING THE STUDY OF SOLID GEOMETRY THROUGH THE USE OF MINERAL CRYSTALS

Jo McKeeby Phillips
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Part II

This is the second of two articles on the topic at hand. Part I, published in the December 1952 issue of School Science and Mathematics, was designed to furnish the subject-matter background concerning mineral crystals, and sought to answer the question, (A) What should the teacher of solid geometry know about mineral crystals if he is to use them for purposes of motivation?

The discussion which follows will attempt to answer two more questions: (B) How may this knowledge be used in the classroom? (C) What materials are necessary, and where may these materials be obtained?

B. *How may this knowledge be used in the classroom?*

The use to which mineral crystals are put in the solid geometry program is determined by many factors including the materials available, the character of the class, and the locality in which you are working. The following paragraphs describe a few ideas which have been successfully used by some teachers.

1. The first day of the course in solid geometry, purely to arouse curiosity, put out everything you have, including magnifying glasses and microscopes, displayed as attractively as possible. The writer made a table cover out of an old black velvet evening skirt and uses that as a background for the more eye-catching specimens in her collection. Have all this ready when the class comes into the room, then busy yourself a few feet away and listen to the comments. "Gosh, this stuff is pretty!" "I wonder if she's going to throw rocks at us." "Do you suppose this would be worth anything if we hocked it?" etc. If you are lucky, you will be bombarded with questions about the minerals. The students are usually astonished when assured that the crystals you have have not been cut, but came from the ground that way. Send someone down to the school cafeteria to borrow a shaker of salt, to convince the students that what you may say later about the cleavage of halite does not apply to a special variety of salt. Ask the students to identify the geometric forms (polygons) which appear as crystal faces. In the more perfect specimens, ask them to identify the polyhedrons. Make whatever remarks and explanations seem reasonable under the circumstances. Let the students handle the minerals. Let them look at salt under a magnifier. If you can spare

the material, let them hit a piece of calcite (limestone is a common variety of calcite) or a piece of galena with a hammer. A small piece of either of these may be almost pulverized and will still show its spectacular cleavage form under a microscope. Ask the students what this cleavage implies. All of them know enough about the structure of matter to realize that you are not smashing any atoms with that hammer. What, then, does the cleavage along a plane indicate? Probably they have seen a model of a crystal of sodium chloride in the chemistry laboratory. How did the people who made that model know that the atoms of sodium and chlorine were arranged in straight lines in perpendicular pairs? One of those rare experiences which keep teachers in the profession occurs when the students see the answer to your question here.

2. When you come to the unit on dihedral angles, crystals may be used to illustrate dihedral angles and are convenient things to handle in finding dihedral angles to measure. A valuable lesson involving vertical angles and the plane angle of a dihedral angle comes from the use of a contact goniometer. A contact goniometer can be purchased for about fifty cents or can be made very easily from a protractor and a suitable pointer. Also, dihedral angles may be measured with an ordinary protractor if swab sticks or pieces of thin but rigid wire are fitted properly on the dihedral angle and the vertical angle between the sticks or wires is measured. The concept of "fitted properly" brings up the definition of the plane angle of the dihedral angle.

3. To demonstrate the definition and the names of various types of polyhedral angles, crystals furnish excellent material.

4. After the unit on polyhedrons, the students will usually appreciate a discussion of the crystal systems. They will have a concrete object to use to facilitate the visualization of symmetry about an axis, symmetry about a plane, and symmetry about a point. Any practice they get in this will help them later in the study of the analytic geometries and the calculus. Even if all this seems useless, there might be far-reaching consequences in getting people to see that there is a beautiful orderliness in the non-political underground.

5. Some students will be interested in constructing models of crystal forms. These might be accepted as optional class work or for a club project. There is one sort of student who learns his mathematics more effectively via his right arm than by any other route. Constructing models helps him particularly. Handling models helps every student; models are a multi-sensory aid. Also, certain methods of model construction involve flattening the surface of the solid figure. Familiarity with this device is valuable to the student who will go on to study advanced mathematics.

6. Minerals furnish many topics for club programs, special reports in class, or optional study.

7. There are limitless possibilities for correlating what may be learned in solid geometry class about mineral crystals with selected topics in geography, geology, physiography, chemistry, or English. A girl might write an essay on "The Diamond, from Mine to *Mine*," or a boy might do one on "The Underground (locality)." If you live in a mining area, interest will be greater in mineral deposits and allied topics.

8. An exhibit in the library, the hall, or your classroom will usually arouse a lot of interest, even among people who have no knowledge of any kind about minerals or about demonstrative geometry. The crystals are pretty.

9. An assembly program using specimens, color slides, and models can be very instructive and entertaining. Unless your assembly group is small, various projectors and a screen are necessary for this.

C. *What materials are necessary, and where may these materials be obtained?*

Minimum equipment would probably include a half-dozen specimens and one book. The book may be already in your school library, and if it is not, the librarian will be glad to secure it for you. (See bibliography below.) Specimens may be collected personally, purchased from mineral dealers, and borrowed or accepted as gifts from friends of the teacher or of the school. In almost every class there are some students who have a few mineral specimens at home that they will be pleased to loan. Sometimes their mothers consider the minerals useless dust catchers and encourage the students to contribute them to a good cause. You will be particularly fortunate in this respect if there are mineral deposits nearby. It is a characteristic of the tribe of amateur collectors of minerals that they enjoy exchanging duplicates with each other. Also, tell all of your friends that you are collecting minerals. Then when they go on trips or summer vacations, instead of bringing you a little bear-in-a-snowstorm paper weight, they can bring you a mineral crystal. Both parties in this transaction will be delighted with it. If you have to buy the specimens you will use, most of the minerals that are best for your purposes are relatively inexpensive—galena, halite ($NaCl$), calcite, quartz, mica, magnetite, feldspar, fairy stone. You can always use salt from the grocery store. A student may prepare some crystals of salt by dissolving as much salt as possible in a small amount of water, pouring the solution into a saucer, and setting this somewhere to crystallize where it will not be disturbed.

It is desirable, in addition to the crystals, to have a microscope and

some magnifying glasses which may be borrowed from the department of science if you do not have some of your own; a small hammer, the ten-cent store variety; one contact goniometer and some protractors; and a few models of perfect crystals, which may be made by the teacher or the students, borrowed from another department, or purchased from a supply house (see bibliography). The best models are very precisely constructed and are imported from Germany. This makes them quite expensive, and frequently as long as a year elapses between the placing of an order and delivery of the merchandise. However, the less elegant factory-built models or the homemade ones are perfectly good for use in the solid geometry classroom.

If you start out with the requisite enthusiasm, your collection of materials and your ideas of how to use them will grow miraculously.

Bibliography—Mineral Crystals and Solid Geometry

Getting Acquainted with Minerals, by George Letchworth English' McGraw-Hill Book Co., N.Y.C., 1936.

From the preface: "The aim of this book is to introduce the charming science of mineralogy in the simplest and most interesting manner possible without sacrificing scientific accuracy. It can be understood readily by a child of fourteen, yet its appeal is equally strong to the adult."

In the opinion of the writer, if you can have just one book on minerals in your library, this one would be the wisest choice.

Minerals and How to Study Them, by the late Edward Salisbury Dana, revised by Corneilius S. Hurlbut, Jr., Third Edition, John Wiley & Sons, N.Y.C., 1949.

From the jacket: "Written for the amateur, this book discusses crystals, properties of minerals, and identification tests, with minerals arranged according to chemical classification. Included are suggestions for starting a well-rounded mineral collection."

This is THE authoritative text on mineralogy. The teacher needs it; the students can use it. It is clearly and simply written. Once you own a copy, you will wonder how you ever got along without it.

Gems and Gem Materials, by Edward Henry Kraus and Edward Fuller Holden, McGraw-Hill, 1925.

As is evident from the title, this book treats the subject from a different point of view. For the minerals it describes, the material is sufficiently complete for our purpose. Using this book, it is possible to trace a diamond from the mine to an engagement ring, with auxiliary ideas about fake gems besides.

A Manual of Geometrical Crystallography, by G. Montague Butler, John Wiley & Sons, N.Y.C.

This is very specific and less elementary than the previous ones.

The Rock Book, by Carroll Land Fenton and Mildred Adams Fenton, Doubleday, Doran & Co., Inc., N.Y.C., 1940.

This book is general and non-technical as far as crystallography is concerned. It furnishes valuable background material about the general composition of the earth and the molecular structure of matter.

* * *

Use also any books that may be available on minerals in your own locality.

For specimens, models, lenses, and equipment of all kinds, even including books, a very satisfactory house to deal with is Ward's Natural Science Estab-

lishment, Inc., P. O. Box 24, Beechwood Station, Rochester 9, New York. Their Catalog of Minerals, Rocks, and Soils is number 494, and their Geology Catalog is number 499.

W. M. Welsh Mfg. Co., 1516 Segwick St., Chicago, Ill., has a set of inexpensive wooden models which do not illustrate all six of the crystal systems, but are very useful for what they do include.

CASE INSTITUTE INAUGURATES UNUSUAL MOTOR DESIGN COURSE

Electrical engineering students at Case Institute of Technology, Cleveland, next February for the first time will have the opportunity to enroll in a new motor design course wherein their own design efforts will actually be incorporated into manufactured motors. Normally such design courses are limited to "paper work" that cannot be checked by actual tests for performance and manufacturing practicability.

Under this new plan, small groups of students will work together in designing motors from one to $7\frac{1}{2}$ horsepower. Their specifications will then be sent to Robbins & Myers, Inc., Springfield, Ohio, where the motors will be built at no charge. The company will then deliver the motors to Case where the students may check their work by making actual tests that are rarely, if ever, possible in normal classroom procedure. The motors will become the property of Case as an adjunct to their regular laboratory equipment.

Before announcing the course, Case staff members carefully reviewed the design techniques used in the Robbins & Myers engineering department. Mr. A. E. Hartman, who will be the class instructor, spent several months working with Robbins & Myers engineers in order to adapt the strictly industrial design processes for classroom instruction. Case officials emphasize, however, that the resulting material is in no sense what might be called a "trade course," since fundamental design theory has not been sacrificed. Work, however, will be calculated around present Robbins & Myers motor laminations in order that student-conceived designs may be built with existing Robbins & Myers production tooling as far as possible.

Dr. Paul Hoover, head of the Case Electrical Engineering Department, has stated that enrollment in this new power-application course already exceeds by more than two times the number of students who have elected the romantic field of electronics.

ATLANTIC FISHING BANKS ONCE PART OF CONTINENT

The offshore banks of New England, Nova Scotia and Newfoundland, famous for their rich fisheries, were once a part of the continental land mass, Dr. Frank Press and Walter Beckmann, Columbia University geologists, told the Geological Society of America.

The geologists said that seismic refraction measurements showed these banks are covered by as much as a two-mile deep layer of continental shelf sediments, indicating they once extended to the shore.

The deep rift valleys that separate the banks from the continental shelf were probably caused by erosion, they said.

Electric cord holder eliminates the unsightly tangle of excess lamp cords at wall sockets. Consisting of a "reel" and a cylindrical case, a single unit can take up as much as nine feet of slack cord, presenting a neat appearance to the housewife and her guests.

OUTLINE OF THE HISTORY OF TRIGONOMETRY

George E. Reves
The Citadel, Charleston, S. C.

I. *The Period before 1600*

A. *The Ancient Period* (3100 B.C.–1 B.C.). Origins were astronomy, geometry and surveying.

1. *Babylonian* (2000 B.C.–1 B.C.): records in cuneiform script on tablets of about 2000 B.C.; tables of Pythagorean numbers, circumferences of circles, equivalents of csc x for x from 31° to 45°; sexagesimal system for angles with 360° in a circle.
2. *Egyptian* (2900 B.C.–1 B.C.): records in picture writing in Moscow papyrus (1850 B.C.) and Rhind papyrus (1650 B.C.); great pyramid (2900 B.C.); obelisks and timepieces (1850 B.C.); cotangents of pyramid angles; no evidence of even a particular case of the Pythagorean theorem.
3. *Chinese* (probably contemporaneous with Babylon and Egypt): records written on paper about 618 A.D. to 907 A.D. of period around 1112 B.C. to 256 B.C.; said to have divided (before 2285 B.C.) circle into 365 degrees; established (2780 B.C.) length of year as 365 days (given the length $365\frac{1}{4}$ days sometime later); special cases (1100 B.C.) of Pythagorean theorem; good estimate (1100 B.C.) of Obliquity of the Ecliptic by angles of elevation of the Sun; handled proportions in sixth century.
4. *Hindus* (1500 B.C.–600 A.D.): no pre-Christian records; special cases of Pythagorean theorem; equivalent rectangles and squares, equivalent circles and squares; fourth century table of sines for every 3.75° up to 90° computed by incorrect rule probably accurate enough for the times (influenced Greeks to use sines instead of chords); knew $\sin^2 x + \cos^2 x = 1$.

B. *The Greek and Roman Period* (600 B.C.–600 A.D.)

1. *Thales* (624 B.C.–547 B.C.): measured heights of pyramids by shadow reckoning, distance of a ship from shore.
2. *Pythagoras* (569 B.C.–500 B.C.) (Pythagorean School until 350 B.C.): Pythagorean theorem; theory of proportion for commensurables; approximated the incommensurable $\sqrt{2}$.
3. *Eudoxus* (408 B.C.–355 B.C.): theory of proportions

applicable to incommensurable and commensurable magnitudes; tried to explain motion of the planets (around the earth).

4. *Euclid* (365 B.C.–275 B.C.): gave Eudoxus' geometric theory of proportions and irrationals; geometry of three dimensions.
5. *Aristarchus* (310 B.C.–230 B.C.): first to say earth and other planets revolved about the sun (anticipating Copernicus by 17 centuries).
6. *Archimedes* (287 B.C.–212 B.C.): found π could be calculated theoretically; gave area of triangle in terms of sides; gave equivalent of

$$\sum_{k=1}^{n} \sin \frac{(2k-1)\pi}{n} = \cot \frac{\pi}{4n}.$$

7. *Eratosthenes* (276 B.C.–195 B.C.): used trigonometry to get a very accurate value of the polar circumference of the earth.
8. *Hipparchus* (161 B.C.–126 B.C.): began trigonometry as a science with his systematic treatment; introduced division of circle into 360° into Greece; used coordinates for position on earth; probably made equivalent of table of sines; knew equivalent of $\sin^2 x + \cos^2 x = 1$.
9. *Heron* (75 A.D.): geometric proof of Archimedes' area of triangle in terms of sides; values of cot $2\pi/n$ for integral n from 3 to 12 inclusive; blended Greek and Oriental methods.
10. *Menelaus* (100 A.D.): wrote six books on the calculation of chords; first definition of a spherical triangle; developed considerable spherical trigonometry.
11. *Ptolemy* (85–165): made sexagesimal fraction more widely known; almost made trigonometry a separate science from geometry; geometrical theorems equivalent to $\text{sid}^2 x + \cos^2 x = 1$ and formulae for $\sin(x \pm y)$ and $\cos(x \pm y)$; table of chords equivalent to sines of angles from 0° to 90° for each 30′; beginnings of spherical trigonometry.

C. *Hindu, Arabic, Persian Period* (600–1200)

1. *Brahmagupta* (early 7th century, Hindu): area of quadrilateral inscribed in a circle; formulae for determining quadrilaterals whose sides, diagonals, and areas are rational quantities; formulae, in terms of any three rational numbers, for lengths of sides of an oblique triangle whose altitudes and areas are rational.

2. *Mahavira* (9th century, Hindu): Heron's formula, extension of Brahmagupta; area of equilateral triangle as $(\sqrt{3}a^2/4)$.
3. *Al-Khowarizmi* (about 850, Arabian): tables of sines and cotangents influenced by earlier Hindus.
4. *Al-Battani* (858–929, Arabian): more prominent use of sine; table of tangents and cotangents for every degree from 0° to 90°; some algebraic methods applied to trigonometry; cosine rule for the spherical triangle.
5. *Abu'l Wefa* (940–998, Arabian): systematized all known trigonometry into a loose deductive system; introduced equivalents of secant and cosecant and used all six trigonometric functions; formulae for versed sine, for tangent and cotangent in terms of sine and cosine, for sine of an angle in terms of sine and cosine of the half-angle; knew $\tan^2 x+1=\sec^2 x$, $\cot^2 x+1=\csc^2 x$; extended Ptolemy's table to include tangents; computed since table for intervals of 15′ with values in eight decimal places; derived sine theorem for spherical trigonometry.
6. *Al-Zarqali of Cardoba Spain* (1029–1087): edited Toledan planetary tables which contained trigonometric tables (probably influenced development of trigonometry in the Renaissance).
7. *Gherareo of Cremona* (about 1150): may have been first to use the name *sinus* although often attributed to *Plato of Tivoli* (about 1150) in his translation of *Al-Battani*.

D. *The Period 1200 to 1600*

1. *Leonardo of Pisa* (1175–1250, Italian): gave (1202) the algebraic identity $(a^2+b^2)(c^2+d^2)=(ac\pm bd)^2+(ad\pm bc)^2$ which could be used as the basis of all trigonometric identities; described (1225) vast amount of geometry and trigonometry learned on his travels in *Practica Geometriae*.
2. *Nasir-Eddin* (1201–1274, Arabian): wrote (1250) first complete plane and spherical trigonometry treated independently of any astronomical application (Europeans later duplicated much of the material without being aware of its existence); used all six trigonometric functions; gave necessary formulae for solving right triangles and all cases of oblique, spherical triangles.
3. *Ulugh Beg* (1393–1449. Persian): table (1435) of sines and tangents for every minute correct to eight or ten decimals for angles 0° to 45° and for every five minutes for angles 45° to 90°.

4. *Peurbach* (1423–1461, Austrian): began computation of table of sines finished later by his pupil *Regiomontanus*.
5. *Muller* (*Regiomontanus*) (1436–1476, German): wrote (about 1464, printed 1533) first European systematic exposition of plane and spherical trigonometry (great influence on subsequent textbooks and upon establishing trigonometry as a science independent of astronomy); area of triangle $\frac{1}{2}ab \sin C$, law of tangents for triangles, law of sines in a spherical triangle, principal formulae of plane and spherical trigonometry; published (1490) table of sines for intervals of one minute; translated Appollonius, Heron and Archimedes.
6. *Rhaeticus* (1514–1576, German): gave (1551) tables (finished in 1596 by pupil *Valentin Otho*) having values of all six trigonometric functions for every ten seconds to ten places, table of sines for every ten seconds to 15 places; first definitions of trigonometric functions as ratios of sides of a right triangle; first table of secants of its kind; used cofunctions and gave tables for angles from 0° to 45° only.
7. *Vieta* (1540–1603, French): formula for $\cos nx$ in terms of $\cos x$ for integral n; laid foundation for analytic trigonometry with the fundamental advance of a systematic application of algebra (obtained many identities algebraically and made elementary trigonometry practically complete except for the computational side); extended (1579) Rhaeticus' tables to seven places for all six functions for every second; solved a 45 degree algebraic equation for 23 of its roots by trigonometry; reduced Cardano's solution of the cubic equation to a trigonometric one.
8. *Stevin* (1548–1620, Dutch): published (1585) first systematic explanation of decimal fractions; advocated decimal division of degrees; used exponential notation for decimals (not the modern notation).

II. *The period after 1600*

A. *The Seventeenth Century*

1. *Pitiscus* (1561–1613, German): gave (1613) tables up to 15 places; formulae for $\sin (x \pm y)$ and $\cos (x \pm y)$.
2. *Napier* (1550–1617, Scotch): invented (1594) logarithms (without knowledge of modern exponential notation); published (1614) explanations of his logarithms and table of logarithms of sines from 0° to 90° for each minute,

suggested using a system with $\log 1 = 0$; formulae for solving general spherical triangles.

3. *Burgi* (1552–1632, Swiss): developed (1603–1611) logarithms independently of Napier; published (1620) table of logarithms.
4. *Kepler* (1571–1630, German): contributed to simplification of computations; published (1624) a volume of logarithms.
5. *Briggs* (1561–1631, English): followed Napier's suggestion and published (1624) a table of logarithms (14 places) using the base ten.
6. *Oughtred* (1579–1660, English): introduced (1618) abbreviations for sine, tangent, cosine and cotangent; invented (1618) radix method of calculating logarithms; first (1618) table of natural logarithms; invented (about 1622) the slide rule.
7. *Gregory* (1638–1675, Scotch): gave (1671) series expansions for $\tan x$, $\text{arc sec } x$, $\text{arc tan } x$.
8. *Newton* (1642–1727, English): gave (1676) series expansions for $\sin nx$ and $\cos nx$.

B. *The Eighteenth Century*

1. *Machin* (1680–1751, English): used (1706) Gregory's series to derive the formula

$$\frac{\pi}{4} = 4 \text{ arc tan } \frac{1}{5} - \text{arc tan } \frac{1}{239}$$

(this relation was used (1853) by *Shanks* (1812–1882, English) to compute π to 707 decimals—only 526 places correct.

2. *Cotes* (1682–1716, English): stated (about 1710) equivalent of DeMoivre's theorem

$$\cos nx + i \sin nx = (\cos x + i \sin x)^n, \ n \text{ an integer.}$$

3. *Taylor* (1685–1731, English): initiated (1713) the idea that the solution of the vibrating string problem could be expressed in terms of trigonometric functions.
4. *Bernoulli, J.* (1667–1748, Swiss): used (1728) a difference equation to obtain a solution for the loaded elastic vibrating string problem in terms of trigonometric functions (a crude approximation to an actual string).
5. *DeMoivre* (1667–1754, French): showed familiarity with the DeMoivre theorem; developed (1730) important

material in analytic trigonometry involving imaginaries.

6. *d'Alembert* (1717–1783, French): used (1747) a partial differential equation to show the solution for the continuous vibrating string had the form $f(x+ct)+g(x-ct)$ with f, g, "arbitrary" functions.
7. *Euler* (1707–1783, Swiss): extended (1748) DeMoivre's theorem to any n; gave exponential form for sine and cosine; introduced many modern trigonometric notations; obtained (1747) the same solution as d'Alembert for the continuous vibrating string with the advanced attitude of a willingness to accept a geometrical definition of "arbitrary" function, while d'Alembert insisted upon certain analytic restrictions upon the function; obtained (1777, published 1793) the Fourier coefficients for the expansion of a function into a cosine series when the function was known to possess such an expansion (did not see method applied to an "arbitrary" function).
8. *Bernoulli, D.* (1700-1782, Swiss): showed (1755) motion of continuous vibrating string was expressible in the form of an infinite series of trigonometric functions, but Euler and d'Alembert objected to the implication that an "abritrary" function could be expressed in terms of an infinite series of periodic odd functions (the controversy raged for some 20 years).
9. *Lagrange* (1736–1813, Italian-French): treated (1759) the continuous vibrating string as the limiting case of a finite set of equally spaced masses on a weightless string and just missed the modern solution given by Fourier analysis since an interchange of the order of taking limits in his solution gives the solution of today.

C. *The Nineteenth and Twentieth Centuries.* Spherical trigonometry developed as a tool for astronomy before the development of plane trigonometry, which is more a tool for surveying. Analytic trigonometry began in the seventeenth and eighteenth centuries. Refusing to heed all objections, *Fourier* (1758–1830, French) made (1807–1822) the final step Lagrange had refused to take and gave the representation of an "arbitrary" function by a trigonometric series in his studies of heat conduction. The first satisfactory proof, with proper conditions for this method, was given (1829) by *Dirichlet* (1805–1859, French). Such studies have led to innumerable applications of analytic trigonometry because the trigonometric functions are the simplest periodic functions and because the sine and

cosine can furnish a set of orthogonal functions (properties which seem fundamental to modern physical science). By 1750 the work of Euler had actually made trigonometry become a province of analysis. All that remained was to derive the analytic formulae with due attention to convergence and to create a self-consistent theory of complex numbers. *Wessel* (1745–1818, Norwegian) gave (1797) a consistent, useful interpretation of complex numbers and fundamental results on the questions of convergence were obtained (1821–1826) by *Cauchy* (1789–1857, French) and others. Thus, the remainder of the history of trigonometry is primarily a part of the history of functions of a real variable and functions of a complex variable.

FELLOWSHIPS AT CASE

High school physics teachers in 12 states will have an opportunity in 1953 to obtain General Electric Science Fellowships at Case Institute of Technology for a special six-week summer program. Now in its seventh consecutive year the program will be offered June 22 to July 31, 1953, according to the announcement of Dr. Elmer Hutchisson, dean of the faculty at Case.

Fifty fellowships will be awarded in recognition of outstanding teaching of high school physics. Applications for the fellowships at Case are invited and application forms may be obtained by writing to Dr. Leonard O. Olsen, Director of the General Electric Science Program, Department of Physics, Case Institute of Technology, Cleveland 6, Ohio.

The fellowships will provide funds to cover travelling expenses to and from Cleveland, living expenses on the Case campus during the program, books, tuition and fees.

The fellowships are open to experienced high school or preparatory school teachers of science who are college graduates and are certified to teach in the field of physics in the states of Illinois, Indiana, Iowa, Kentucky, Michigan, Missouri, Ohio, Western Pennsylvania, Tennessee, West Virginia or Wisconsin.

In addition to the academic program conducted on the Case campus, Science Fellows will devote two afternoons a week to visiting the Nela Park laboratories of the General Electric Company and other outstanding research laboratories in greater Cleveland such as the Lewis Flight Propulsion Laboratory of the NACA. Special evening lectures by national leaders in science are included in the program as are recreational features.

The General Electric Science Fellowship Program, of which the courses at Case are a part, also includes summer courses for secondary school physics and chemistry teachers given by Union College, Schenectady, N. Y. to serve teachers in the northeastern states, summer courses for high school mathematics teachers given by Rennselaer Polytechnic Institute, Troy, N. Y.; and a summer program for high school mathematics teachers at Purdue University, Lafayette, Indiana, which will be offered for the first time in 1953.

Roof coating, resembling aluminum paint, reflects heat from the sun, prolonging the life of industrial roofs and lowering below-roof temperatures by 13 to 26 degrees. Brushed or sprayed on, a gallon of the coating covers about 300 square feet of roofing.

AGE, VETERAN STATUS AND SUCCESS IN COLLEGE PHYSICS

Sam Adams
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A pronounced cycle can be traced in the literature regarding the college work of veterans. After the GI Bill became law, but before demobilization really got under way, many college administrators seemed to accept the idea that academic standards would necessarily be adapted to the questionable ability of the veterans. A feeling of relief because such adjustments did not become necessary led many college officials to issue glowing reports, frequently without substantiating data, regarding veteran superiority. However, a relatively large number of careful studies were made regarding veterans and their scholastic progress.

Problem

A great many of the studies dealing with the scholastic progress of veterans were based on a general average or on a point-hour ratio. Somewhat fewer dealt with achievement during a particular college year. Very few have been concerned with work in a particular college course.

In this investigation an effort was made to evaluate the achievement of veterans in a course of sophomore college physics. The work of the veteran group was compared to that of nonveterans, and an attempt was made to investigate the performance of these two groups in terms of student age.

Data

At Louisiana State University two types of sophomore physics courses are offered. One, called "General Physics," is designed for students who do not plan to major in a physical science field. Those who do plan to follow a physical science or engineering curriculum take "General Physics for Technical Students." The two courses appeared to be quite similar, so that they were combined for statistical treatment.

Marks were used as indicators of achievement, since no other system has gained extensive usage. Numerical equivalents were assigned to letter marks as follows: A=4, B=3, C=2, D=1 and F=0. Since this study dealt with students who completed both terms of a physics course, the number equivalents of the two semester marks were added to arrive at a year mark. Hence a student who earned two A marks had a year mark of eight.

During the regular sessions of 1947, 1948, and 1949, a total of 1,467

students enrolled in a beginning physics course at Louisiana State University. The second course of the sequence was completed by 988, or about 67%, of this group. Incomplete records ultimately reduced the usable group to 877 students.

Necessary data as to student age were available for 716 members of the latter group, while veteran status could be definitely established for 787 of the group. Both age and veteran status were available for 690 individuals.

Method of Analysis

It was found that student age at the time of beginning of college physics course ranged from 16 to 31. For purposes of statistical treatment, two-year step intervals were used. Four classifications were used as to veteran status: (1) nonveterans, (2) Louisiana veterans, (3) out-of-State veterans, and (4) all veterans.

As has been mentioned earlier, "achievement in college physics" was arrived at by adding the numerical equivalents (A=4 to F=0) of the two semester marks.

These data were reduced to a relatively simple code, and the statistical treatment was greatly expedited by the use of IBM equipment.

Results

Studies of the scholastic records of veterans have produced widely varying results. Indeed, to assume that they were all good or all bad students would be ridiculous. Probably the best records were established by those veterans who returned to college immediately after demobilization. It has been said that many who returned to school several years after discharge were "graduates of the 52–20 clubs." Since the present study was based on students who were enrolled in

Table I. Age Distribution According to Veteran Status

Age	Non-veterans	Louisiana Veterans	Out-of-State Veterans	All Veterans
30–31		2		2
28–29	1	12	2	14
26–27	3	15	4	19
24–25	3	35	10	45
22–23	17	77	16	93
20–21	54	105	21	126
18–19	278	9	2	11
16–17	23	1		1
Total	379	256	55	311
Mean	19.388	22.368	22.464	22.384
Sigma	.671	1.22	1.15	1.20

a sophomore course in 1947, 1948 and 1949, probably a fair cross section was involved.

Table I shows the age distribution according to veteran status for those 690 students whose records were complete.

It will be noted that there was a fairly equal representation of veterans and nonveterans in this group, and that the mean age of the veteran group was almost exactly three years higher than that for the nonveteran group.

Table II shows the achievement of various age groups in college physics.

TABLE II. ACHIEVEMENT IN COLLEGE PHYSICS ACCORDING TO AGE

Age	Number of Cases	Mean Year Mark College Physics	Sigma
26–up	41	6.31	1.70
24–25	49	4.77	1.74
22–23	112	4.46	1.71
20–21	186	5.03	1.76
18–19	304	4.69	1.70
16–17	24	5.01	1.80
Total	716		

Many studies show a tendency for younger students to excel. However, the 16–17 year group here was only slightly superior to several others, and their mean year mark fell below that of two other groups. One plausible explanation is that the type of mind which might serve to get a student graduated from high school at an early age might not excel when confronted with the type of work found in college physics.

One might well speculate on whether or not the relatively slight differences of means among the five lower age groups had any statistical significance. However, there was no question that the 26-and-above group did outstanding work in physics. This group of 41 students had a B-plus average, with a mean year mark 1.28 higher than that of their nearest competitor.

In Table III is shown the achievement in college physics according to veteran status.

If one compared the physics achievement of the veteran group to that of the nonveterans, he would find no appreciable difference. The only group showing even a slight degree of superiority was the out-of-state veterans, and this may or may not have been meaningful.

It was possible to compare physics achievement of veterans and

TABLE III. ACHIEVEMENT IN COLLEGE PHSYICS ACCORDING TO VETERAN STATUS

Veteran Status	Number	Mean Year Mark College Physics	Sigma
Nonveteran	403	4.779	1.76
Louisiana Veteran	324	4.674	1.72
Out-of-State Veteran	60	4.987	1.87
All Veterans	384	4.72	1.74

nonveterans within three particular age groups—the 18–19, 20–21 and 22–23 year groups. In no case was there a difference which appeared to be significant, but in all three groups, the mean year mark for the nonveterans was slightly higher than for the veterans.

CONCLUSIONS

This study dealt with achievement in college physics from the standpoints of student age and veteran status. In this particular course, the marks of veterans and nonveterans did not appear to be significantly different. Indeed, if a difference did exist, it was in favor of the nonveteran group. The only age group showing a definitely superior record was 26–and-above. Since this group was composed almost entirely of veterans, it would be impossible to attribute their superior work exclusively to either factor.

In the large body of literature dealing with veteran education, a preponderance of material tends to show some degree of veteran superiority. Under the conditions used in this study, no such superiority is in evidence. In short, within the relatively narrow limits of this particular investigation, there appears to be nothing about war service which served to convert poor students into good students.

SULFUR OBTAINED FROM UNDER MARSHLAND

Sulfur, one of industry's most important raw materials, is now being extracted from a deposit deep under the Bay Ste. Elaine in the Louisiana marshland, the Freeport Sulphur Company reported.

The water-borne plant pours nearly 2,000,000 gallons of hot sea water a day into the bed to melt the sulfur, which is then transported in insulated barges to storage 75 miles away. Only one of its kind, the plant will mine 100,000 long tons of sulfur per year.

The new mining technique employed holds promise for the future development of similarly situated deposits.

Slat cleaner for Venetian blinds grips both sides of the slat with sponge-like jaws, removing dirt and grime as the device is slide along the slat. Having a built-in cleaning-fluid reservoir, the device permits the housewife to clean her blinds without taking them down.

VITALIZING THE CLASSROOM—PICTORIAL MATERIALS

Sam S. Blanc
East High School, Denver 6, Colo.

Pictorial materials may be defined as those visual aids which present to the pupils concepts in the form of organized ideas of some specific object or organism. Picturization of the real thing or an illustrative representation of that thing in black-and-white or color will be considered in this section. Pictorial materials for use in science may be divided into two general classes, unprojected and projected. This discussion will deal with materials which do not require special preparation for projection.

Every science teacher uses pictures in his teaching. Pictures have definite values in classroom procedure. As early as the seventeenth century, Pestalozzi began using illustrations in his teaching. With the advent of photography and mechanical means of reproduction, pictures have become an everyday part of the pupils' classroom experiences. It is easily seen that pictures may be used to arouse interest, introduce a new topic, illustrate steps in a process, build good attitudes, and develop appreciations.

In selecting materials for class use, the teacher is confronted with the problem of how to choose, from the wealth of materials available, the few good pictures which can be used to make the classwork more meaningful. It is true that each of the various types of pictorial materials has its own unique possibilities for science instruction. However, all pictorial materials have a common basis for instruction; the presentation to the pupil of concepts, ideas, and generalizations in a visual manner as distinguished from a verbal manner. The science teacher must be able to distinguish and select appropriate types of pictures for definite instructional purposes. As a matter of good teaching technique every teacher should have general guidelines in mind at all times in relation to this area of instruction. The criteria for the selection of pictures may be discussed under the following headings: instructional characteristics, compositional characteristics, and physical characteristics.

Instructional Characteristics:

1. Relevancy of the picture to the instructional program
2. Truthfulness of the impression the picture creates in the minds of the pupils
3. Stimulativeness and emotional impact the picture will have on the pupils
4. Authenticity and contemporaneousness of the objects or ideas depicted

Compositional Characteristics:

1. Simplicity and unity of the picture in directing attention to one center of interest

2. Representation of some common object in the picture to enable pupils to judge relative sizes
3. Artistic proportions of the picture should be pleasing to the viewer
4. Coloring in the picture attractive and accurate

Physical Characteristics:

1. Technical quality of focus, balance, and lighting accurate
2. Spots, blemishes, and glare on the picture not present
3. Size of the picture suitable to use that will be made in display or individual study
4. Mounting material substantial and harmonizing with predominant colors in the picture
5. Surface of picture protected against soiling and wear

As with any good teaching procedure, the teacher must prepare carefully if the lesson is to be effective. This would include the selection of the pictures, their arrangement in the order to be used, the analyzing of each picture in relation to the unit to be studied, and the formulating of guide questions to draw the pupils into the discussion. The presentation of the lesson should include the use of the pictures as an introduction to a unit so that they follow an unified concept in the minds of the pupils. Such points as using only a few pictures at a time to avoid confusion in the minds of the pupils, arranging the pictures so that all pupils in the room can see them clearly, adjusting the lights and shades so that the picture will not reflect glare, and placing the pictures on stable mounts as they are being discussed are small, but important, points in utilization. The pupils should be allowed time for individual study in examining the pictures. Each pupil has a different rate of comprehension, and this phase of the work must be adjusted to that factor. The pictures might be arranged on a table or in a file accessible to the pupils, and they could then obtain the pictures they wanted for study at their seats.

In the testing step, it is possible to summarize with the class the main ideas presented by the pictures, and to check the extent of the learning by means of written questions or essays. Follow-up activities might include such things as developing questions which arise from the primary activity into additional units of work, encouraging pupils to carry on reading and further study as a result of the interests aroused, and allowing pupils to bring in additional materials to supplement the pictures used.

The stereograph is also a flat picture in its makeup, but to obtain the three-dimensional effect for which it is designed, it is photographed through a special camera and it must be viewed through a stereoscope. At present there has not been developed a feasible method of projecting three-dimensional stereo-slides for classroom use. There is one such projector on the market, but it employs the use of polarized glasses to be worn by the viewer, and does not yet

seem to be perfected to the point where it might be used to advantage in a classroom situation.

The stereograph is designed for individual use. The telebinocular is a heavy instrument with excellent lenses and a built-in source of illumination. The ordinary hand-held stereoscope should be familiar to all teachers. The viewmaster is a small instrument designed as a toy, but it has its place in elementary science where its low cost makes it possible for a whole class to be equipped with viewers. However, the stereographs for use in this instrument are of a special type and cannot be used in a standard stereoscope. A new camera has been placed on the market whereby a teacher can now photograph his own viewmaster stereographs.

The stereograph has a unique place in education for it is the only pictorial material which the pupil may actually see in three dimensions. It is true that good photography employs the use of perspective to give an illusion of three dimensions, but the stereograph actually permits the pupil to see the third dimension. Because of this, the stereograph presents a true-to-life picture into which the child may actually feel himself transported. But due to the fact that this type of material may only be used for individual study, not many classrooms have stereographs for general use.

The selection of stereographs may be subjected to the same criteria as other types of unprojected pictorial materials. The same elements of instructional, compositional, and physical characteristics may be applied to stereographs as to flat pictures. It is only in the fact that these materials are adapted for individual study that they are treated apart from other pictures. With this point in mind, the teacher should be able to apply the suitable principles for utilization developed earlier in this article. The principles of preparation, presentation, individual study, testing, and follow-up are just as applicable to this group of materials as they are to flat pictures. It is necessary to remember that stereographs encompass a great deal more detail for the pupil than flat pictures of a similar nature; hence, more time is needed for full comprehension. The individual study should be done at a study table or the pupil's seat. Attempting to pass a stereoscope among the pupils while the lesson is progressing would only result in confusion, and could be an unjustified waste of time.

Many science teachers find that the flat pictures selected for class use are of such nature that they may not be used for individual study by the pupils, or that enough time is not available to allow each pupil to study the pictures by himself. Yet, the pictures have something to contribute to the understanding of the unit being considered which may not be gained in any other way. In this situation the projection of the picture by means of an opaque projector is a

logical step. The opaque projector may be used to project an image of the picture on a screen in any well-darkened room. Due to the fact that this type of projector places the image on the screen by *reflection*, rather than by *transmission* of light, a good source of illumination is necessary.

In the older types of projectors that was one disadvantage of this piece of equipment. The heat generated by the high-wattage lamp was often so great that the picture was scorched if left in the projector for any great length of time. Also, due to the fact that extremely large lenses were needed to project the entire object, most of the older projectors were designed to take a picture no larger than 6″×6″ in size. Newer types of projectors which have recently been placed on the market overcome both of these objections. With an improved cooling system, the picture may be left in the machine for a considerable length of time without danger of scorching. The size of the projection area has also been increased to 11″×11″, and yet, the projector has actually been made lighter through the use of lightweight alloys. The light output has also been increased so that a satisfactory image may be projected in a semi-darkened room.

The criteria for selection of opaque materials and the principles for their utilization will follow closely the points listed previously for the selection and utilization of other pictorial materials. The only additional factors are that the room must be darkened and the seating of the pupils must be so that all can see the screen. Since the windows are usually closed when the room is darkened, the teacher must bear in mind that the physical comfort of the room, such as heat and ventilation, must be checked if the lesson is to be carried on under the best conditions.

PATENT DELAYED BY SECURITY

An inventor has just got a patent after waiting 19 and a half years for it.

Chester T. Minkler, a Newport, R. I., Navy employe, received patent number 2,617,703 for a torpedo recording mechanism for which he applied May 9, 1933. The patent application was not granted for security reasons, a Navy spokesman said.

The recorder is a camera fitted into a practice torpedo. It takes a picture of the target ship at the moment the torpedo is supposed to go off. It is used in torpedoes which explode when they come near a target without actually hitting it. This underwater "proximity fuse" torpedo, only revealed after World War II, was the reason for keeping the invention secret.

Flannel suits and slacks for men now are being made of a material that is 60% wool and 40% acrylic fiber. The fiber makes the suit hold its shape. Pants hold their creases even when soaking wet. Longer wearing, the lightweight material is warm and has a woolly feel.

RESEARCH—SERVANT OR MASTER?

WILLIAM B. REINER
Board of Educational Research, 110 Livingston St., Brooklyn 2, N. Y.

PHILOSOPHY OF VALUES

Science education, like all education, has its roots nourished by a philosophy of values. In a democracy which respects individual rights and yet strives to develop group cooperation, these values will determine the curriculum, methodology, and evaluation of science education. In a democracy which is challenged by the forces of dictatorships which foster the complete submergence of personal individuality, a renewed self-analysis is needed. Other problems beset us. Are we veering toward a crass materialism? Are our spiritual values suffering because of our hectic pace of living? Is the family losing its stabilizing influence?

CURRICULUM

Upon what values and principles shall our curriculum development be based? If our philosophy of values is to foster democratic living in which the rights of the individual to live in an atmosphere of harmony with other free men, in a wholesome, spiritual, and family setting, then our curriculum makers are obliged to include these in their objectives.

Where does science education enter in these objectives? There is much in the cultural and historic aspects of science teaching that can be used to develop wholesome group living, democratic ideals, and respect for the individual's life and feelings. The curriculum makers must consider the needs, interests, abilities, experiences, and readiness of the children for their curriculum goals and objectives. Research helps to determine these. The teacher in the intimate setting of his or her classroom can further adjust the goals to the pupils there.

The matter of curriculum has many unsolved problems. What emphasis shall be given to information, reasoning, or attitude development? In a democracy is a knowledge of facts more important than ability to analyze propaganda? If facts are more important, which ones shall we teach? If analysis is more important, how shall we teach it? At what grades shall certain areas, units, problems, or topics be taught?

METHODOLOGY

The methods we use depend upon the curriculum we use. The learning materials, visual aids, and types of activities are dependent upon the aims that have been set. There are many unsolved problems

in this area. Shall we use pupil planning or teacher planning, homogeneous grouping of pupils by ability or heterogeneous grouping, teacher demonstrations or pupil laboratory exercises? How effective is the activity or core plan?

In many cases a direct answer is not obtainable because it is difficult to control the single variable experimental factor. Here we are compelled to make judgments on the basis of what data are available, limited though they may be. However, the problems are there, waiting to be solved.

Our philosophy of values will determine our methodology insofar as pupil-teacher relationships are concerned. In an authoritarian society, the teacher is the complete master, the child is subservient, competition is stressed, mental hygiene is neglected, and group cooperation is not encouraged. The psychology and sociology of the culture is reflected in the classroom.

In a free atmosphere, the correctness of techniques of teaching may be questioned and then be put to experimental tests. Research will check upon a methodology whose nature was originally determined by a philosophy of values.

Evaluation

Evaluation is a check on the adequacy of our curriculum and the effectiveness of our methodology. What we evaluate depends on what we teach and how we teach it. The evaluation programs of the past were measures of the pupils' memorization of facts. More recently instruments to evaluate scientific reasoning have been developed. Tests of aptitude and attitude are needed, particularly on the elementary level. Inventories of pupils' interests are being constructed by teachers.

The philosophy of values determines the evaluation programs. Tests are given not only for grade purposes, but to help pupils determine their progress. Tests are not instruments of coercion. Devices other than written pencil-and-paper tests are used. Appraisal of personality and social aspects of the pupils are made. Habits of study are appraised.

Teachers are encouraged to construct their own tests using technical skills and measuring modern objectives.

Conclusion

Our philosophy of values is firmly interwoven through the tapestry of our science education. It determines the design of the curriculum, methodology and evaluation programs. The philosophy of values is dependent in the last analysis upon our ethical and spiritual values. Constant analysis of our trends and directions are needed to check

our course. Research can help verify our progress. Research is a servant rather than a master in guiding us toward our objectives in our educational and social experiences.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2307, 2319. *C. W. Trigg, Los Angeles City College.*

2313, 4, 5. *Mart E. Mitchell, Plainfield, Ill.*

2317–2322. *Martin Schmookler, Scranton, Pa.*

2317. *Julian H. Braun, Washington, D. C., R. L. Moenter, Fremont, Neb.*

2318. *C. W. Trigg, Los Angeles City College; Julian H. Braun, Washington, D. C.; Richard H. Bates, Milford, N. Y.; R. L. Moenter, Fremont, Neb.*

2319, 20. *Julian H. Braun, Washington, D. C.*

2321. *Richard H. Bates, Milford, N. Y.; R. L. Moenter, Fremont, Neb.*

2322. *Julian H. Braun, Washington, D. C.; R. L. Moenter, Fremont, Neb.*

EDITOR'S NOTE: The published solution of **2301** implied a property of ln x in line 2, which is not valid as noted by Richard A. Miller, University of Mississippi. Below is his solution, which is essentially the solution given in most of those offered.

2301. *Proposed by Roy E. Wild, Moscow, Idaho.*

Use the definition:

$$\ln x = \int_1^x \frac{dt}{t},$$

to show that $\ln x^2 = 2 \ln x$.

If

$$\ln x = \int_1^x dt/t,$$

then

$$\ln x^2 = \int_1^{x^2} dt/t. \qquad x>0.$$

By the change of variable $t=y^2$, $dt=2ydy$, then the limits of integration are changed from 1, x^2 to 1, x.

Thus

$$\ln x^2 = 2\int_1^x dy/y = 2 \ln x.$$

2323. *Proposed by C. W. Trigg, Los Angeles City College (a challenge to high school pupils).*

From a right circular cylinder, radius R and length h, there is turned a symmetrical spindle composed of two truncated cones, joined at their small bases, which have a radius r. Find the ratio of the volume of the spindle and the cylinder in its simplest form, and determine its minimum value.

Solution by Leon Bankoff, Los Angeles, Calif.

$$\text{Vol. Frustum of Rt. Circ. Cone} = \frac{\pi h'}{3}(R^2+Rr+r^2)$$

$$\text{Volume of Spindle} = \frac{2\pi h'}{3}(R^2+Rr+r^2)$$

$$= \frac{\pi h}{3}(R^2+Rr+r^2)$$

$$\text{Vol. Cylinder} = \pi R^2 h$$

$$\frac{\text{Vol. Spindle}}{\text{Vol. Cylinder}} = \left(\frac{R^2+Rr+r^2}{3R^2}\right).$$

Theoretically the minimum value of this ratio is obtained when $r=0$, and the ratio becomes 1/3. Practically the spindle becomes two right circular cones, no longer truncated.

C. W. Trigg also offered a solution.

2324. *Proposed by Jefferson Hurst, Warren, Pa.*

Use the indirect method to prove that the altitudes of a plane triangle are concurrent.

Solution by Leon Bankoff, Los Angeles, Calif.

Assume that altitudes AD and BE intersect in H and that altitude CF cuts altitudes BE and AD in J and G respectively. Then, triangles ABE and EJC are similar, since their corresponding sides are perpendicular, and $JE/AE = EC/EB$ (1). Now, triangles EBC and AEH are also similar, for the same reason, and $EH/AE = EC/EB$ (2). Then, by (1) and (2), $JE = HE$, and J coincides with H.

Since J lies on CF, CF passes through H and the three altitudes meet in only one point.

Solutions were also offered by Matie Smith, Romulus, N. Y. and Walter R. Warne, Syracuse, N. Y.

2325. *No solution has been presented.*

2326. *Proposed by V. C. Bailey, Evansville, Ind.*

Prove that

$$1+\frac{1}{3}-\frac{1}{5}-\frac{1}{7}+\cdots=\frac{\pi}{2\sqrt{2}}.$$

Solution by Richard H. Bates, Milford, N. Y.

From Maclaurin's expansion for arc tan θ:

$$\text{arc tan }\theta=\theta-\frac{\theta^3}{3}+\frac{\theta^5}{5}-\frac{\theta^7}{7}+\cdots$$

letting $\theta=1$:

$$\frac{\pi}{4}=1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\cdots$$

and dividing both sides by 2.

$$\frac{\pi}{8}=\frac{1}{2}-\frac{1}{6}+\frac{1}{10}-\frac{1}{14}+\cdots. \tag{1}$$

The expansion of $f(x)=x$ in a Fourier Series in the interval $-\pi<x<\pi$ gives:

$$x=2\left(\sin x-\frac{\sin 2x}{2}+\frac{\sin 3x}{3}-\frac{\sin 4x}{4}+\cdots\right)$$

and letting $x=\pi/4$:

$$\frac{\pi}{4}=2\left(\frac{1}{\sqrt{2}}-\frac{1}{2}+\frac{1}{3\sqrt{2}}-0-\frac{1}{5\sqrt{2}}+\frac{1}{6}-\frac{1}{7\sqrt{2}}-0+\frac{1}{9\sqrt{2}}-\frac{1}{10}+\frac{1}{11\sqrt{2}}-0+\cdots\right).$$

Dividing by 2 and grouping every other term:

$$\frac{\pi}{8}=\frac{1}{\sqrt{2}}\left(1+\frac{1}{3}-\frac{1}{5}-\frac{1}{7}+\frac{1}{9}+\frac{1}{11}-\cdots\right)-\left(\frac{1}{2}+\frac{1}{6}-\frac{1}{10}-\frac{1}{14}+\cdots\right). \tag{2}$$

Substituting (1) in (2) in the second member:

$$\frac{\pi}{8}=\frac{1}{\sqrt{2}}\left(1+\frac{1}{3}-\frac{1}{5}-\frac{1}{7}+\cdots\right)-\frac{\pi}{8}$$

$$\frac{2\pi\sqrt{2}}{8}=\frac{\pi}{2\sqrt{2}}=1+\frac{1}{3}-\frac{1}{5}-\frac{1}{7}+\cdots.$$

Solutions were also offered by John O. Chellevold, Waverly, Iowa; Leon Bankoff, Los Angeles; C. W. Trigg, Los Angeles City College, who offered the following:

This is problem 22, page 335 of Part II of Chrystal's *Algebra*, Sixth Edition. It is also problem 32, page 318 of Hobson's *Plane Trigonometry*, Fourth Edition. Solutions to it appeared in the *American Mathematical Monthly*, *53*, 467 (Oct. 1946).

2327. *Proposed by Edna Barrett, Hall's Corners, N. Y.*

Construct the plane triangle ABC, given hypotenuse c, the area, and $\angle A - \angle B$.

Solution by C. W. Trigg, Los Angeles City College

Since we are given the hypotenuse c, we also have $\angle C = 90°$. These together with area, S, and $\angle A - \angle B$ constitute four data, whereas only three are necessary to construct the triangle. On $AB = c$ as a diameter construct a semicircle.

Now if S and c are given, h_c is implied, for if S is given in the form of a straight-sided, plane polygon a triangle of equivalent area can be constructed on c as *base*. At a distance equal to h_c draw a line parallel to AB. The intersection of this line with the semicircle is the third vertex of the triangle. Thus the triangle is constructed without using $LA - LB$.

In any triangle $\angle A + \angle B + \angle C = 180°$ or $\angle B = \frac{1}{2}(180° - \angle C - (\angle A - \angle B))$. Hence, at the end B of the diameter of the semicircle erect a perpendicular BD. Construct $\angle DBE$ equal to $\angle A - \angle B$ so that BE falls inside $\angle ABD$. Bisect $\angle ABE$. Clearly, this bisector will intersect the semi-circle at C. Thus the triangle is constructed without using S.

Solutions were also offered by Leon Bankoff, Los Angeles; Margaret Joseph, Milwaukee; Warren R. Smith, Sutton's Bay, Mich.; Victor H. Paquet, Milwaukie, Oregon; Richard Englebrecht, Waverly, Iowa; Richard H. Bates, Milford, N. Y.

2328. *Construct the equilateral triangle, ABC, given R its circumscribed radius.*

Solution by Frank Flickinger, Wartburg College, Waverly, Iowa

Construct any equilateral triangle $A'B'C$. Draw CD, bisector of angle C. Draw $CO = R$ with O as center and R as radius construct the circumcircle. Extend CA' to meet the circle at A, and CB' at B. Join A at B.

Triangle ABC is the required triangle. The proof follows easily.

Solutions were also offered by C. W. Trigg, Los Angeles City College; W. R. Smith, Sutton's Bay, Mich., Henry Bull, Wolcott, N. Y.; Carolyn Luther, Oneonta, N. Y.; Grace Taylor, Bertha, Minn.; Bruce Le Seur, Hector, N. Y.; Matie Smith, Romulus, N. Y.; George Dann, Phoenix, Ariz.; Maude Hansen, Brown Valley, Minn.; Alice Yerkes, Tarrytown, N. Y. and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

2317. *Ted Burton, Toronto; David Yale, Toronto; Ken Watson, Toronto; Douglas Macanachu, Toronto.*

2321. *Douglas Macanachu, Toronto.*

2322. *Ted Burton, Toronto; Ken Watson, Toronto.*

2328. *Barbara Voysey, Pittsburgh.*

2311, 3, 4, 2323, 7, 8. *Robert Glahn, Kirksville, Mo.*

PROBLEMS FOR SOLUTION

2341. *Proposed by C. W. Trigg, Los Angeles City College.*

P is any point of the surface of the sphere inscribed in one of the five regular

polyhedra (Platonic Solids). Show that the sum of the squares of the distances from P to the vertices is constant.

2342. *Proposed by C. W. Trigg.*

1. Find the three smallest consecutive even integers each of which is the sum of the two squares greater than zero.
2. Show that no three consecutive odd integers can each be the sum of two squares greater than zero.

2343. *Proposed by Anna Jessop, Hayts Corners, N. Y.*

Prove

$$\sqrt{2}=\frac{4\cdot 36\cdot 100\cdot 196\cdot 324\cdot \cdots}{3\cdot 35\cdot 99\cdot 195\cdot 323\cdot \cdots}.$$

2344. *Proposed by Georgia V. Rolison, Andover, N. Y.*

Solve $\tan\theta+\sec 2\theta=1$

2345. *Proposed by Mrs. J. B. Rooney, East Springfield, N. Y.*

The area of a quadrilateral $ABCD$ with diagonals h and k is C. Find the area of the square, each side of which contains one of the points A, B, C, D.

2346. *Proposed by Leon Bankoff, Los Angeles.*

A realtor exchanged two square plots with integer sides and of different areas for one rectangular plot equal to the combined area of the other two. He then subdivided the rectangular plot into eight square plots with integer sides, each of which was smaller than either of the two original square plots. What are the least possible dimensions of the plots, using one yard as a unit?

BOOKS AND PAMPHLETS RECEIVED

QUANTITATIVE ANALYSIS, by William Marshall MacNevin, *Professor of Analytical Chemistry*, and Thomas Richard Sweet, *Assistant Professor of Analytical Chemistry, The Ohio State University.* Cloth. Pages ix+247. 13.5×21 cm. 1952. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $3.75.

SCIENCE MAGIC, by Kenneth M. Swezey, *Author of After-Dinner Science.* Cloth. Pages x+182. 14.5×23 cm. 1952. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $3.75.

A GENERAL ZOOLOGY OF THE INVERTEBRATES, by G. S. Carter, *Fellow of Corpus Christi College and Lecturer in Zoology in the University of Cambridge.* Cloth. Pages xxviii+509. 13×21.5 cm. Third Edition, 1948. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.75.

INTRODUCTION TO THE FOUNDATIONS OF MATHEMATICS, by Raymond L. Wilder, *Research Professor of Mathematics, University of Michigan.* Cloth. Pages xiv+305. 14.5×23 cm. 1952. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.75.

MATERIALS AND PROCESSES, by Max Kohn, *Chairman*, and Martin J. Starfield, *Department of Industrial Processes, Brooklyn Technical High School.* Cloth. Pages vii+483. 13.5×21 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y.

DICTIONARY OF GAMES, Compiled by J. B. Pick. Cloth. 318 pages. 12×20.5 cm.

1952. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

EVOLUTION IN THE GENUS DROSOPHILA, by J. T. Patterson and W. S. Stone, *Professors of Zoology in the University of Texas.* Cloth. 610 pages. 13.5×21 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $8.50.

MR. WIZARD'S SCIENCE SECRETS, by Don Herbert. Cloth. 264 pages. 13.5×21.5 cm. 1952. Popular Mechanics Press, 200 East Ontario Street, Chicago, Ill. Price $3.00.

YOUR COMMUNITY'S HEALTH, by Dean Franklin Smiley, A.B., M.D., *Secretary of the Association of American Medical Colleges, Chicago, Illinois,* and Adrian Gordon Gould, Ph.B., M.D., *Colonel, Medical Corps, Army of the United States Retired List.* Cloth. Pages xiv+454. 13.5×21 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.50.

THE METHODS OF STATISTICS, Fourth Edition, by L. H. C. Tippett, *British Cotton Industry Research Association.* Cloth. 395 pages. 13.5×21.5 cm. 1952. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.00.

BASIC BIOLOGY FOR HIGH SCHOOLS, Revised Edition, by Carroll Lane Fenton, Ph.D., and Paul E. Kambly, Ph.D., *Professor of Education and Director of Supervised Teaching, University of Oregon.* Cloth. Pages ix+726. 14.5×21 cm. 1953. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y.

PHYSICAL CHEMISTRY, Third Edition, by Frank H. MacDougall, M.A., Ph.D., *Professor Emeritus of Physical Chemistry, University of Minnesota.* Cloth. Pages xi+750. 13.5×21 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $6.00.

HIGH FIDELITY SIMPLIFIED, by Harold D. Weiler. Paper. Pages xi+208. 13.5×21 cm. 1952. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $2.50.

THE OUTDOOR SCHOOLROOM FOR OUTDOOR LIVING, by William Gould Vinal, *Professor of Nature Education at Boston University, Boston Massachusetts.* Paper. 70 pages. 15×22.5 cm. 1952. Dr. William G. Vinal, R.F.D. Vinehall, Cohasset, Mass. Price $1.00.

A BIBLIOGRAPHY OF REFERENCE BOOKS FOR ELEMENTARY SCIENCE, by George Greisen Mallinson, *Western Michigan College of Education, Kalamazoo, Michigan,* and Louis Marion Mallinson, *Kalamazoo, Michigan.* Paper. 49 pages. 21×28 cm. National Science Teachers Association, 1201-16th Street, N.W., Washington, D. C.

RECORDINGS FOR TEACHING LITERATURE AND LANGUAGE IN THE HIGH SCHOOL, by Arno Jewett, *Specialist for Language Arts.* Bulletin 1952, No. 19. Pages iv+71. 15×23.5 cm. Superintendent of Documents, U. S. Government Office, Washington 25, D. C. Price 25 cents.

ARMED SERVICES EXAMINATIONS MATHEMATICS, by Elmer A. Habel, *Pensacola Junior College, Pensacola, Florida.* Paper. 39 pages. 21.5×28 cm. 1952.

TEACHING MATERIALS AVAILABLE FOR MATHEMATICS CLASSES, by Kenneth P. Kidd, Ph.D., *Associate Professor of Education, University of Florida, Gainesville, Florida.* Paper. 26 pages. 21.5×28 cm.

HOW CHILDREN AND TEACHER WORK TOGETHER, by Elsa Schneider. Bulletin 1952, No. 14. Pages iii+24. 15×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

CONSERVATION—NATURAL RESOURCE USE WORKSHOP. Prepared by the California State Departments of Education and Natural Resources held at Fresno State College, Fresno, California. Paper. Pages vi+134. 21×28 cm. July 28–August 22, 1952. Department of Natural Resources, State Office Building No. 1, Sacramento 14, Calif.

ELECTRICAL DEMONSTRATIONS YOU CAN PERFORM. Paper. 31 pages. 16.5×24 cm. 1952. Westinghouse Electric Corporation, Box 2278, Pittsburgh 30, Pa.

BOOK REVIEWS

PLANTS OF THE BIBLE, by Harold N. Moldenke, Ph.D., *Curator and Administrator of The Herbarium, New York Botanical Garden,* and Alma L. Moldenke, B.A., *Biology Department, Evander Childs High School, New York, N. Y.* Pages xx+328. 18.5×25 cm. 1952. Chronica Botanica Co., Waltham, Mass. Price $7.50.

This is one of the really great books of the present time—a must for all students of the Bible. Ministers and Sunday-school teachers will find it most helpful in preparation of sermons and for their teaching. It represents a large part of the work of twelve years of diligent study, letter writing, library work, and travel.

Following the title page and frontispiece, which is a beautiful picture of the Cedars-of-Lebanon, are several highly instructive pages consisting of preface, contents, beautiful illustrations, a long list of the illustrations used throughout, and a list of plates at the end of the book. Also there is a most interesting eleven-page historical sketch, a full page vegetation map of Palestine, a description of the land, and a section of five pages of "Helps to Users of this Work."

Then follows the body of the text, consisting of 228 pages on the plants arranged in alphabetical order. Under each initial letter are several sections with Bible references, referring to the plant or group of related plants. Thus under 1. *Acacia nilotica* and 2. *Loranthus acaciae* is the reference, Exodus 3: 2–4, with the quotations, which refer to the "burning bush" seen by Moses. In the discussion the authors suggest that the flame may have been the crimson-flowered parasitic mistletoe often found growing on the acacia as host. In the second group they point out that the *Acacia tortilis* is without doubt the shittah tree from which the arc of the tabernacle, also its altar and table, were made.

Farther along the giant cedars of Lebanon are described as great trees up to 120 feet in height and 8 feet in diameter, which grew in great forests in the Lebanon Mountains at the time of the building of the grand temple, but now have disappeared except in one small valley 6,500 feet above sea level. Here only a small grove remains. The lumbermen employed by the wise King Solomon, and those who lived after him, destroyed the mighty forest by excessive lumbering and left the country denuded.

On another page it is shown that the "rose-of-Sharon" of Solomon's song is not our present rose-of-Sharon, which was introduced into this country from China, but it may have been a crocus as suggested in the Revised Version.

In similar manner all Biblical plants are discussed, telling the exact plant referred to, where this is possible, or giving the various possibilities suggested by others. Many plants, now growing in the Holy Land and having names such as have been put into the language of the Bible by the many translators, are shown not to be natives of the region and were not known in Biblical times.

Following the body of the text are a number of other very important sections including a list of unidentified plant references, a bibliography of 16 pages, 18 pages of supplementary notes, a 36 page index, and a wonderful 36 page set of illustrations.

G. W. W.

DEAD CITIES AND FORGOTTEN TRIBES, by Gordon Cooper. Cloth. 160 pages. 13.5×21.5 cm. 1952. The Philosophical Library, Inc., 16 East 40th Street, New York, N. Y. Price $4.75.

This is a remarkable little book which tells briefly of a number of interesting cities and tribes of the rather recent past. But the author has taken too many subjects to tell very much about any group in a book of 160 pages. After a short introduction giving just a sentence or two about many interesting names and places, which he never mentions again, he tells of the Vikings of Greenland in a short chapter and of the early Indian tribes of northwest Canada in a few pages more. A short chapter on the Mayans of southern Mexico, three pages on the Aztecs, and a few pages more on the Jivaros of Peru and Bolivia follow. In a similar manner he tells of four tribes in old Africa: the "Kingdom of Tafilelt" in the northern Sahara, the Tuareg, or the people whose men wear the veil, one thousand miles south of Algiers, the ruins of Zimbabwe in Southern Rhodesia, and the "web-footed" of Northern Rhodesia. Two short chapters from the south seas follow; then two in the middle east, one in Arabia and one in the country of the high mountains of the Caucasus. The book closes with short stories of three regions in Asia: first, the island of Ceylon off the coast of India, with its famous temple ruins, the four-faced towers, and the terrace of elephants; second, the beautiful and wonderful Anghor of Cambodia; third, the country of Sikkim to the north of India. As he finishes the last sentence the reader wants to know more. He has already turned to the fly-leaf picture maps, but these tell little more. He has looked at the numerous illustrations which show much but not enough. The book is wonderful to stir up the reader's desire for further reading, more pictures and better ones, and most of all the desire to see the places described.

G. W. W.

METEOROLOGY, AN ELEMENTARY TEXTBOOK, by Jas. R. Wilson, *Phoenix Union High School* and R. J. Hannelly, *Dean of Phoenix College*. Paper. Pages iv+92. 21×27 cm. 1951. Printery Publishing Co., Phoenix, Arizona.

This is a beginning book for a very short course in the subject without drawing heavily from other texts. The topics are discussed in an interesting manner, using numerous illustrations, graphs, and a few pictures. The cloud plates are not exceedingly clear, due to the type of the paper stock used. Also it is difficult to see much difference between the illustrations of the *cumulus* and the *cumulus humilus*. Most of the figures used are reproductions of rough sketches such as would be used in freehand blackboard drawings. Even the legends are not set in regular type. Each chapter is closed with a summary of important items and a short list of questions. Many words are used in discussions or drawings but not defined until later in the book or only an incomplete definition given then; e.g., the word *monsoon* prominent in the diagram of Fig. 11 on page 20 but not defined until page 80. In the index under *monsoon* reference is made to Fig. 53 page 64 but it is not stated here that the path of the monsoon is represented. The book may be a good first edition for the author's classes but will require much alteration before adoption by many teachers in other schools.

G.W.W.

ELEMENTARY DIFFERENTIAL EQUATIONS, by Earl D. Rainville, *Associate Professor of Mathematics, The University of Michigan*. Cloth. Pages xii+392. 13×20.5 cm. 1952. The Macmillan Company, New York 16, N. Y. Price $5.00.

The first 208 pages of this book seem identical with the content of the author's *Short Course in Differential Equations*, reviewed in the January, 1952 issue of SCHOOL SCIENCE AND MATHEMATICS. For this reason this review is primarily concerned with material beyond that point. The longer book contains sufficient material for a year course. In the preface, the author points out that the brief text was not written with the idea of incorporation into a longer text, but production costs made this necessary. As a result, three chapters appear at the end of the

text, supplementing earlier chapters with material which would necessarily be omitted from a short course. Topics discussed in such supplementary chapters include solutions involving nonelementary integrals; the Wronskian, Leibnitz' rule for the n'th derivative of a product, systems of equations, the *c*- and *p*-discriminant, and certain applied problems, such as velocity of escape from the earth and Newton's law of cooling.

Beyond page 208 of this text, the author treats (in more detail than is found in most elementary texts) the power series method, with discussion of solutions near an ordinary point and of solutions near regular singular points, and a brief consideration of solutions near an irregular singular points, and a brief consideration of solutions near an irregular singular point. The chapter on numerical methods seems unfortunately brief. There is a short chapter on partial differential equations, and chapters of 30 and 20 pages respectively on Fourier series and on boundary value problems.

Whether or not this text will be considered satisfactory is largely a question of the particular course in mind. The author is inclined to approach the subject from the viewpoint that a detailed study of a few applied topics is of more value than brief content with many applications. As indicated previously, some may feel that their particular course needs more attention to numerical methods than seems given in this text. The text is exceptionally well written, and if the content seems suited to the course in mind, by all means this book should be considered as a text.

CECIL B. READ
University of Wichita

MATHEMATICAL MODELS, by H. Martyn Cundy, *Sixth Form Mathematical Master, Sherborne School*, and A. P. Rollett, *Formerly Senior Mathematical Master, Sevenoaks School.* 240 pages. 13.5×21.5 cm. 1952. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y., Price $4.25.

The teacher seeking information on the construction of models finds descriptions of the ordinary run of figures, but beyond this point is faced with many problems. Even if references are found, they are often unavailable, for the most part. This book is a splendid collection of suggestions for model construction, in particular the models are such as could be constructed and understood by high school students.

Although we often associate models with solid geometry, this book has a chapter on models in plane geometry, including such topics as dissection problems, the use of envelopes, mechanical devices for drawing curves, curve stitching, paper folding. There is a splendid list of algebraic and polar curves which could be drawn for exhibition.

In the reviewer's opinion, the outstanding portion of the book is that dealing with polyhedra. Complete directions are given for construction of the thirteen Archimedean solids, the four Kepler-Poinsot star solids, to say nothing of stellated Archimedean polyhedra. Surely some students would be thrilled with a successful model of five cubes in a dodecahedron, or five octahedra about an icosahedron, to mention only two of many interesting ones.

There is a discussion of wire and wood models, ruled surfaces, Mobius strips, methods of modelling surfaces, linkages, machines for solving equations (including an elementary model or two of an electrical machine).

Certainly this book helps fill a long felt need. Many teachers will ask why it has not been written earlier, and will wish a personal copy as well as one in the school library. The fact that the book is written in England results in some unfamiliar terms, usually when discussion of materials for models is given—for example, Perspex, Juneero strips, Halo rings, shirlastic, Diakon cement. This is a very minor handicap in the use of the book. The reviewer selected a few models at random, ones which sounded interesting, and found the instructions adequate to enable one not particularly adept in using his hands to make a very acceptable

model. No misprints were noted in going over the book; on page 149 one wonders why the polygons in Figure 183 are called hexagons—they appear to be quadrilaterals.

CECIL B. READ

SYSTEMATIC COLLEGE CHEMISTRY, by Lytle R. Parks, *Professor Emeritus of Chemistry*, and Warren H. Steinbach, *Professor of Chemistry, University of Miami, Florida*. Cloth. Pages viii+692. 15×23 cm. 1952. The Blakiston Company, 1012 Walnut, Philadelphia 5, Pennsylvania. Price $5.50.

This text seems to the reviewer to follow a logical order of presentation. Part one, called "Principles of Chemistry," deals with fundamental principles and basic concepts, the three possible physical states, the laws of chemical combination, the atomic theory of John Dalton (and the student is able to see how such a theory explains the laws of chemical combination), symbols, formulas, and equations, the structure of the atom, the periodic tables, oxidation-reduction equations and nomenclature, solutions, and chemical equilibrium.

Part two is called "The Non-metals." It is not until on page 257 that the descriptive chemistry of a single element is considered. Oxygen is given a fairly thorough treatment, as in turn the other non-metals are.

Part three devotes over 100 pages to "The Metals." Part four is called an "Introduction to Organic Chemistry." Parts five and six are composed of study questions, drill exercises, and tests.

The authors seem to have accomplished the objective stated in their introduction: "The material presented herein is no crazy quilt work of topics difficult to relate one to another. Coverage and presentation have been integrated until the wide amount of subject matter covered in the term chemistry is unified and related."

The reviewer noted the absence of journal or book references at the end of each chapter. It is hoped that a later revision may include these. The reviewer was also surprised at the rigid statement of the law of conservation of mass as found on page 48: "Whenever a chemical change takes place, the total weight of the reacting substance is exactly equal to the total weight of the products of the reaction." If the author or anyone using this text finally has occasion to consider Einstein's relation, $e=mc^2$, he will have to side-step and back down from this rigid statement.

The reviewer feels that in the main this is an excellent textbook and believes it will have a rather wide adoption.

GERALD OSBORN
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Kalamazoo, Michigan

QUANTITATIVE CHEMICAL ANALYSIS, by Leicester F. Hamilton, and Stephen G. Simpson, *both of Massachusetts Institute of Technology*. Pages xvii+529, 14×20 cm. Cloth. 1952. The Macmillan Company, New York, N. Y. Price $4.50.

This excellent textbook now appears in its tenth edition. It was originally published as Talbot's *Quantitative Chemical Analysis* in 1897. In spite of the advent of numerous new texts in the field, this long time favorite deserves a high ranking in its field.

The new edition shows a sizeable expansion of 90 pages over the ninth edition. A large part of the added space is taken up with a new section on Instrumental Methods. The treatment here might be considered by some to be too brief, but at least it serves to acquaint the student with these increasingly important methods which have served, in most cases, to reduce markedly the time required for analysis.

A number of new determinations have been included. Among these are titration of phosphate mixtures, arsenic in arsenious oxide, phosphoric anhydride in apatite, ammonia and chlorine in drinking water, and crude fat and fiber in foods.

Newer developments discussed are ion-exchange methods of analysis, chromatography, and amperometric methods.

The authors have furnished an adequate background of theory and have been successful in their effort to include only enough physical chemistry to explain analytical principles. The chapter on precision of analytical measurements is well done and should give students the necessary information on such topics as errors, significant figures, and rejection of measurements—material that is too often neglected in the course. The techniques of quantitative analysis are clearly and thoroughly explained. This is of utmost importance since the acquisition of a good technique by a student in the course is absolutely essential. Experimental directions are complete and lucid. The numerous notes give much valuable information that is essential for the various analyses. A large number of excellent problems are included at the end of the chapters which are sufficient to give students the thorough drill they need in the calculations of quantitative analysis.

The statement on page 92, "... little is gained in the understanding of analytical chemical principles by the Bronsted convention, and the old definition of acids, bases, and salts will therefore be retained in this text," is open to question. When titrating a carbonate or a phosphate, if the student thinks of the phosphate and carbonate ions as bases he realizes there is no great difference between these titrations and that of an hydroxide base.

Students would gain additional facility in analytical calculations if they were required to determine the volume of concentrated hydrochloric acid for their standard acid, and the weights of other reagents required for standard solutions instead of furnishing these amounts. This gives them an opportunity to solve problems with a definite objective in mind.

The book is well written. It includes enough determinations to make a selection that should satisfy any teacher. Quantitative Analysis is basic to all branches of chemistry and should be taught with the aid of a good text. This text is definitely that.

LAWRENCE G. KNOWLTON
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GENERAL CHEMISTRY, Sixth Edition, by H. G. Deming, *Visiting Professor of Chemistry, University of Hawaii.* Pages xii+656, $23\frac{1}{2} \times 15$ cm. Cloth. 1952. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, Limited, London. Price $5.00.

The sixth edition of Deming's famous text is up to the high standard which he set long ago. The writing is of fine quality so that the average college student will find it easy to comprehend and interesting.

The emphasis on chemical principles and many applications from the field of industry are continued. The atomic theory is now introduced very early in the development. The table of contents is arranged in a unique manner to separate chapters which are primarily concerned with principles from those which are primarily descriptive. Dr. Deming also includes suggestions for various possible arrangements of course material.

The layout is excellent and the text is remarkably free of typographical errors. There are many fine illustrations, both drawings and half tones, which are well chosen and well reproduced.

This textbook which has been widely used for almost thirty years will undoubtedly continue to hold its place of eminence in the field.

LILLIAN MEYER
Western Michigan College of Education
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TRIGONOMETRY, PLANE AND SPHERICAL WITH TABLES, First Edition, by Lloyd L. Smail, *Professor of Mathematics, Lehigh University.* Pages xii+406. 1952. McGraw-Hill Book Company, Inc., New York. Price $3.75.

This book is certainly a full modern treatment of plane and spherical trigonometry. The author intends that the text be used primarily for colleges and technical schools. It could, however, be used for substantial courses in the secondary schools. The content of the text is similar to that found in most other trigonometries, but also includes a fuller treatment of other items that are either omitted or only briefly described in other texts. Graphs of trigonometric functions, the inverse functions, functions of compound angles, complex numbers, and the haversine formulas for spherical triangles receive greater attention than is given in most texts. The text is very well adaptable to courses of varying lengths as well as to the varying levels of mathematical maturity of the students. The introduction with the general angle is good. Polar coordinates follow immediately after the discussion of rectangular coordinates. It is very well written as a foundations course for the calculus and other mathematics courses. The choice of problems from navigation and aviation, surveying, mechanics, physics, and astronomy is excellent. A rather full discussion of accuracy in computation is presented. A chapter on logarithms is included at the end, but this is so written that it could be introduced at any point desired. Exeecises of the main type occur in pairs, the odd numbered ones with answers and the even numbered ones without answers. Careful attention has been given to the selection of tables. The general appearance of the printed page is good, but the problems are given in small print. The diagrams and illustrative materials are good. Because of the very great number and variety of problems some of the pages tend to have a crowded appearance. The book deserves careful examination by anyone contemplating a new text in trigonometry.

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Second Algebra, First Edition, by Virgil S. Mallory, *Professor of Mathematics State Teachers College, Montclair, New Jersey*, and Kenneth C. Skeen, *Head of Department of Mathematics, Union High School and Junior College, Taft, Calif.* Pages vii+480. 1952. Benj. H. Sanborn and Company, Chicago.

The text offers a second course in algebra for secondary school students. The psychological organization along with the logical sequence of the topics indicates the rich experience of the authors in the secondary school classrooms. The content is so organized that it is readily adaptable for either a one semester course or a full year course. The material is graded to provide for the individual differences and interests of the students. Chapters I through VI are a review of first year algebra, although written from a more advanced viewpoint. Chapters VII through XI contain the ordinary work of traditional intermediate algebra treating such topics as quadratic equations, logarithms, progressions, the binomial theorem, and the trigonometric functions. Chapter XII contains such topics as the factor and remainder theorem, synthetic division, determinants, differentiation of a polynomial, determination of maxima and minima, integration of simple forms, and the interpretation of integration as the area under a curve is discussed. The exercises in helping the student to keep up with his arithmetic, the inventory tests, and the reviews at the ends of the chapters are very well organized. The diagrams and illustrations are excellent as is the general appearance of the printed page.

T. E. Rine

NATURE BOOKS

Two animal books and the bob white

Freddy Fox Squirrel, by R. W. Eschmeyer. Cardboard. 49 pages. 12.5×17 cm. 1952. Fisherman Press, Inc. Oxford, Ohio.

CHARLEY COTTONTAIL, by R. W. Eschmeyer. Paper. 50 pages. 12.5×17 cm. 1952. Fisherman Press, Inc., Oxford, Ohio.

BOB WHITE, by R. W. Eschmeyer. Cloth. 50 pages. 12×17 cm. 1952. Fisherman Press, Oxford, Ohio. Price $1.50.

These three books for little people are beautifully illustrated in color, tell interesting facts about the life of each wild pet, his habits, food, friends and enemies. Each book is an interesting narrative which keeps the attention of the young reader while he learns the story of the hero, his benefit to the land and people, and the serious effects if his relatives become too numerous. Thus the child learns much of the natural history of his immediate neighborhood while he is just reading a book for pastime and pleasure.

Three books on plants

THANKS TO TREES, THE STORY OF THEIR USE AND CONSERVATION, by Irma E. Webber. Cloth. 60 pages. 16×19.5 cm. 1952. William R. Scott, Inc., 8 W. 13th Street, New York 11, N. Y. Price $2.00.

WHAT'S INSIDE OF PLANTS?, by Herbert S. Zim. Cloth. 32 pages. 15×20.5 cm. 1952. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $1.75.

PLAY WITH LEAVES AND FLOWERS, by Millicent E. Selsam. Cloth. 64 pages. 15.5×20.5 cm. 1952. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

The first book gives in story form many of the uses of trees which children seldom think of unless their attention is directed to them, often much later in their study of physical geography, botany, or agriculture. Many drawings and pictures in color hold the interest and help tell the story.

The second is a picture-story book for children and their parents. Little ones will enjoy the bright pictures while their parents read the stories to them. Second and third grade children will read for themselves but will have plenty of questions for their parents. Even many parents will learn much from both text and pictures.

The third is another of the interesting series: *Play with Plants*, *Play with Trees*, and *Play with Vines*. This book has five short chapters, each one dealing with a special trait. In "Leaves Move" the folding of clover leaves at night takes about half the chapter. Red kidney beans, honey locust, telegraph plant, and others follow. In the second chapter, "Leaves Catch Insects," the sundew and Venus flytrap hold the spotlight. Under "Flowers Move" the author has a number of subjects including goatsbeard, chicory, morning glory, primrose, moonflower, and many others that change as they are affected by light or heat. Chapter four tells of the explosion of seed pods to scatter the seed, and Chapter five gives other interesting traits of plants. The many drawings were made by Fred F. Scherer.

Another bird book

BIRDS AND THEIR NESTS, by Olive L. Earle. Cloth. 64 pages. 16.5×20.5 cm. 1952. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

If you want to learn about birds and their nests and many other interesting things about our feathered friends, here is the book for you. Forty-two bird families, mostly from North America but a few as the ostrich, the penguin, the edible swift, and the hornbill are from distant lands. Beautiful pictures accompany each discussion of the bird, its nest, shape and color of its eggs, and many of its habits.

Anatomy for little children!

WHAT'S INSIDE OF ME?, by Herbert S. Zim. Cloth. 32 pages. 15×20 cm. 1952. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $1.75.

Yes, an excellent first volume on anatomy for little children. Easy reading, beautiful pictures in color, interesting diagrams that tell many things the child should know about many of the most important organs of his body. Just a lot about the body every child should know in order to care for it well.

G. W. W.

DOES IT RAIN HARDER AFTER A LIGHTNING DISCHARGE?

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In a recent trip from New Orleans to Los Angeles I had the good fortune, for the first time in all my travel of this region, to witness firsthand two frightfully severe mountain storms in the desert country. As is well known, summer storms may be infrequent in the Arizona desert, but when they do come they are astonishing sights to witness. That they are not alien events to the region is attested to by the frequency of the *dips* in the highway. These may occur at intervals of 1000 feet, more or less, and are designed to channel the water across the highway as it comes down from the mountain slopes. (For strangers the highways ride like a roller-coaster; down-and-up, down-and-up.) Indeed, too great a speed can raise havoc with car and passengers, since the change of direction imparts phenomenal forces to the vehicle.

Now the question to which I give attention here is this: does the rain fall faster *after* a lightning discharge than before? I believe the question has been considered although I cannot right now locate a reference. My own observation in two storms appears to bear out the conjecture. If, after raining at a rate R, say (mass of water per unit time), during a quiescent time (a calm, so to speak), there occurs a lightning flash, the rain pretty nearly at once falls *faster* and *harder*. The reason for this, if it be so, could be the following: if the upper and lower parts of the cloud are oppositely charged, as they may well be, the rain is retarded by electrostatic forces. When the cloud discharges to earth these forces disappear, in large part at least, and the rain now falls *freely* under gravity.

Interested observers might communicate their observations.

THOUSANDS OF HIGH SCHOOL SENIORS TACKLE SCIENCE TALENT SEARCH TEST

More than 15,000 of the nation's high school seniors recently participated in a three-hour aptitude test, the first hurdle they must overcome to share in the Westinghouse science scholarships offered by the annual Science Talent Search. The science examination is being administered by local school officials in all 48 states and the District of Columbia.

From this number, 40 students will be chosen to share in $11,000 worth of scholarships. The search finals will be held in Washington, D. C. during a five-day Science Talent Institute beginning February 26, 1953. Also considered in choosing the winners are science project reports submitted by the entrants, regular scholastic records, and teachers' evaluation of the students' abilities.

The boy or girl adjudged the most promising will be awarded a four-year, $2,800 Westinghouse Grand Science Scholarship. Other scholarships, ranging from $2,000 to $100, will also be given. In addition to the 40 finalists, 260 winners of honorable mention will be recommended for scholarships to colleges and universities.

The search, now in its 12th year, is open to all seniors in secondary schools throughout the United States. It is conducted by Science Clubs of America through Science Service. It is sponsored by the Westinghouse Educational Foundation which is maintained by the Westinghouse Electric Corporation.

THE DRY SOUTHWEST

"Climatic shifts changed the American Southwest from the grass-carpeted land discovered by the first white explorers some 400 years ago into the desert and dry arroyo, to be found today," says Sheldon Judson, University of Wisconsin professor of geology.

In an article entitled "Arroyos," Prof. Judson says that "when the Spanish explorers of America first came to the U. S. Southwest some 400 years ago, they found it a land of grassy meadows, green valleys, and clear running streams.

"Today the once green valleys are arid and deeply gashed by dry, ugly gullies. What has caused this grim change in the landscape?" Judson asks.

"Most people lay the blame upon man's misuse of the land, but recent investigations," he continues, "have given us a new and somewhat surprising view of the erosion story in the Southwest."

"The present arroyos which cut away grazing and farm land and which quickly drain the region of what little water does fall, have only been developed within the past 65 years," Judson says. Grazing by over-optimistic cattlemen who ran large numbers of animals into the land have always been blamed for destroying vegetation that held the soil down and absorbed rainfall.

"Evidence piled up during recent years, beginning with the work of the late Kirk Bryan of Harvard University, indicates that this raid upon the vegetation was only a trigger force, setting off a process which had already been primed by natural causes," Judson writes.

"The major factor apparently was a slight change in the pattern of rainfall in the Southwest," he adds.

Records during the past 100 years show little change in total annual rain. "But Luna B. Leopold of the U. S. Geological Survey, after analyzing the records, recently turned up the significant fact that in the last half of the 19th century the Southwest's rainfall seems to have been made up of an unusually large proportion of heavy rains over one inch and an unusually small proportion of light ones," Judson writes.

"It is heavy rain," Judson points out, "that does the damage while light rain helps build up vegetation cover." By looking at the walls of arroyos and from other geological evidence, it is to be concluded that this is not the first time the Southwest has lost its greenery.

"At least two and probably three cycles of erosion swept across the Southwest in the past and were later healed by fresh deposits washed over the valleys by resurgent streams," he adds.

"Not much can be done to heal scars of climatic change," Judson says. "It is extremely doubtful that even the strictest control of grazing, combined with "upstream engineering," will bring alluviation of the arroyos unless it is accompanied by sufficiently effective precipitation," he continues.

"We seem, however, to be on the upswing of the climatic cycle," Prof. Judson concludes. "Apparently the cycle of erosion and rehealing that occurred before the conquistadors came took about 200 years. Although recovery will be slow, nature with human aid should once more make the Southwest the green grassland that the Spaniards found four centuries ago."

"Plastic glue," complete with nylon brush applicator, joins plastic airplane models and mends broken plastic toys and dishes. Although many broken articles will stick together if held for 10 seconds after the glue is applied, best results are obtained if the glue is allowed to set an hour.

Film cleaner, because of its fast-drying properties, speeds up the cleaning of commercial movie film by 10% to 20% in machine operations. The cleaner effectively dissolves and washes away gums and oils that "dirty up" photographic film. It does not harm the emulsion of black-and-white or color film.